THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

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MAY 1956

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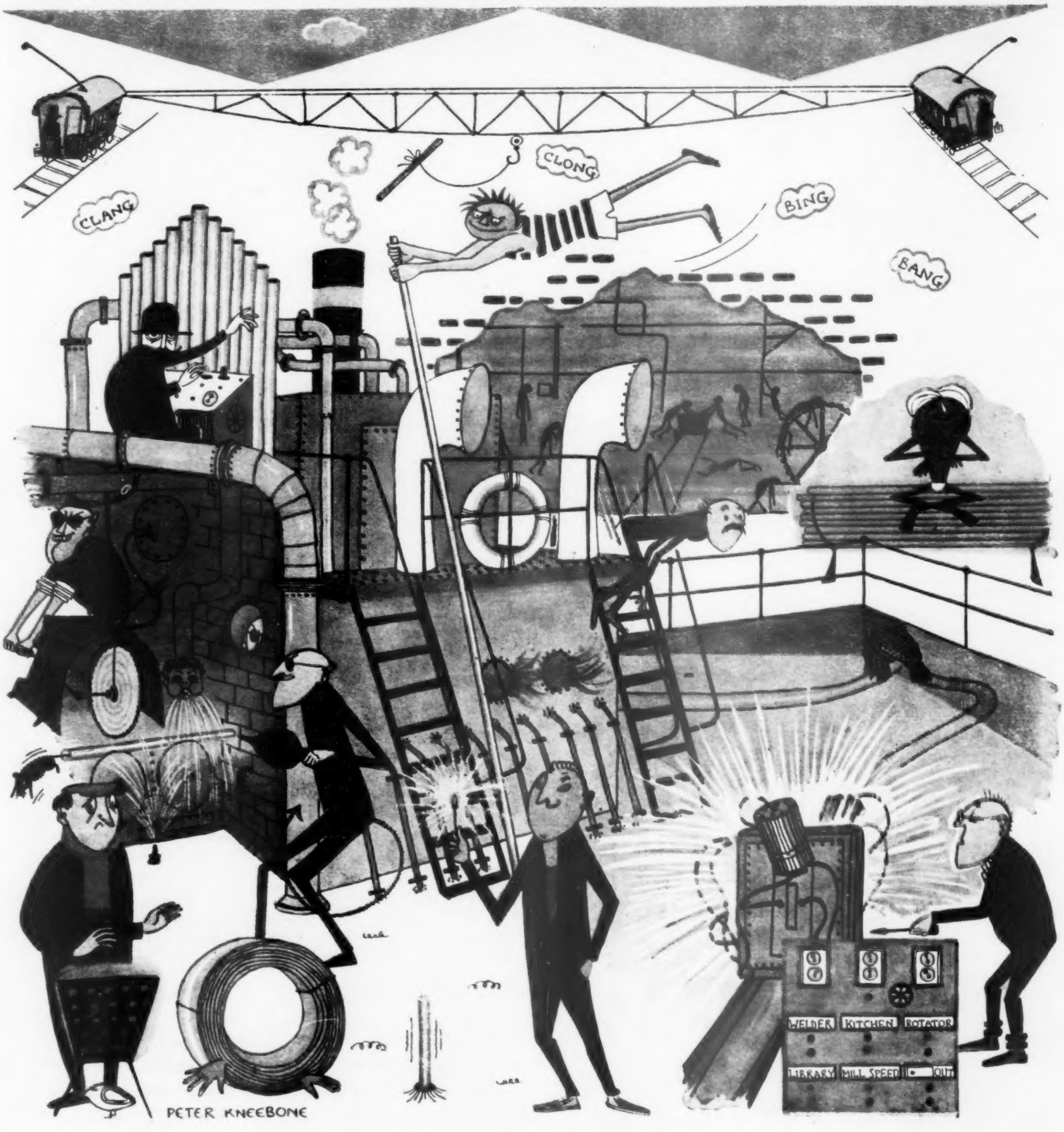
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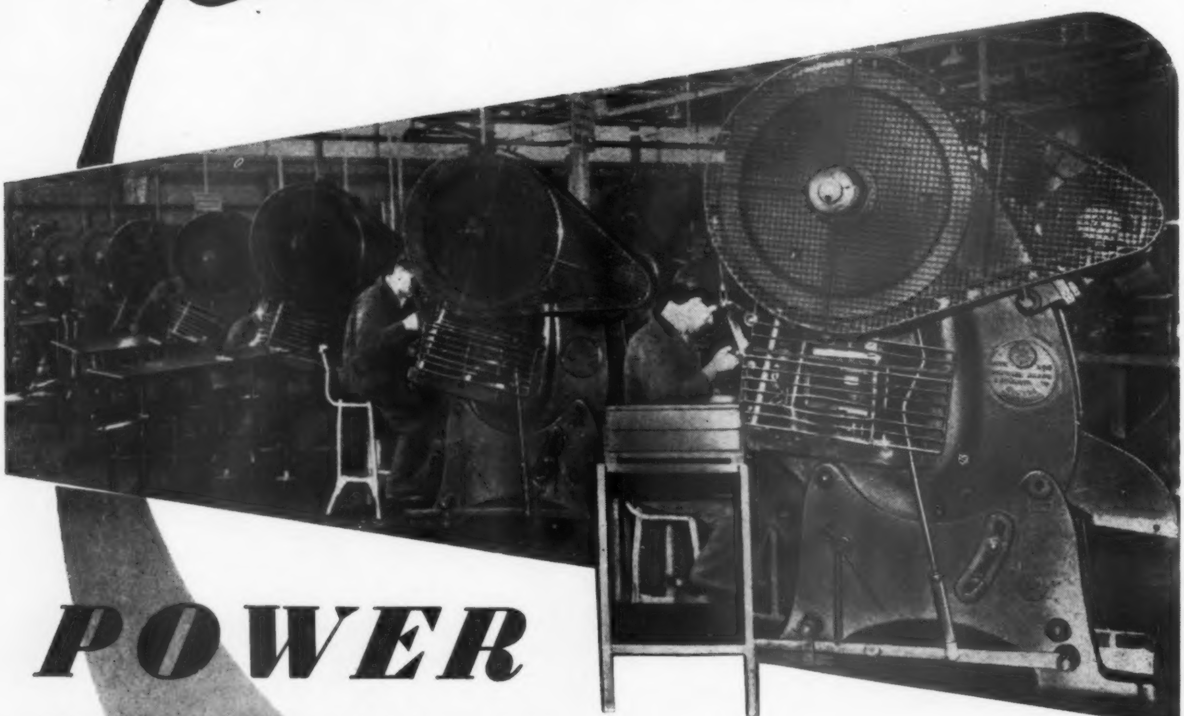

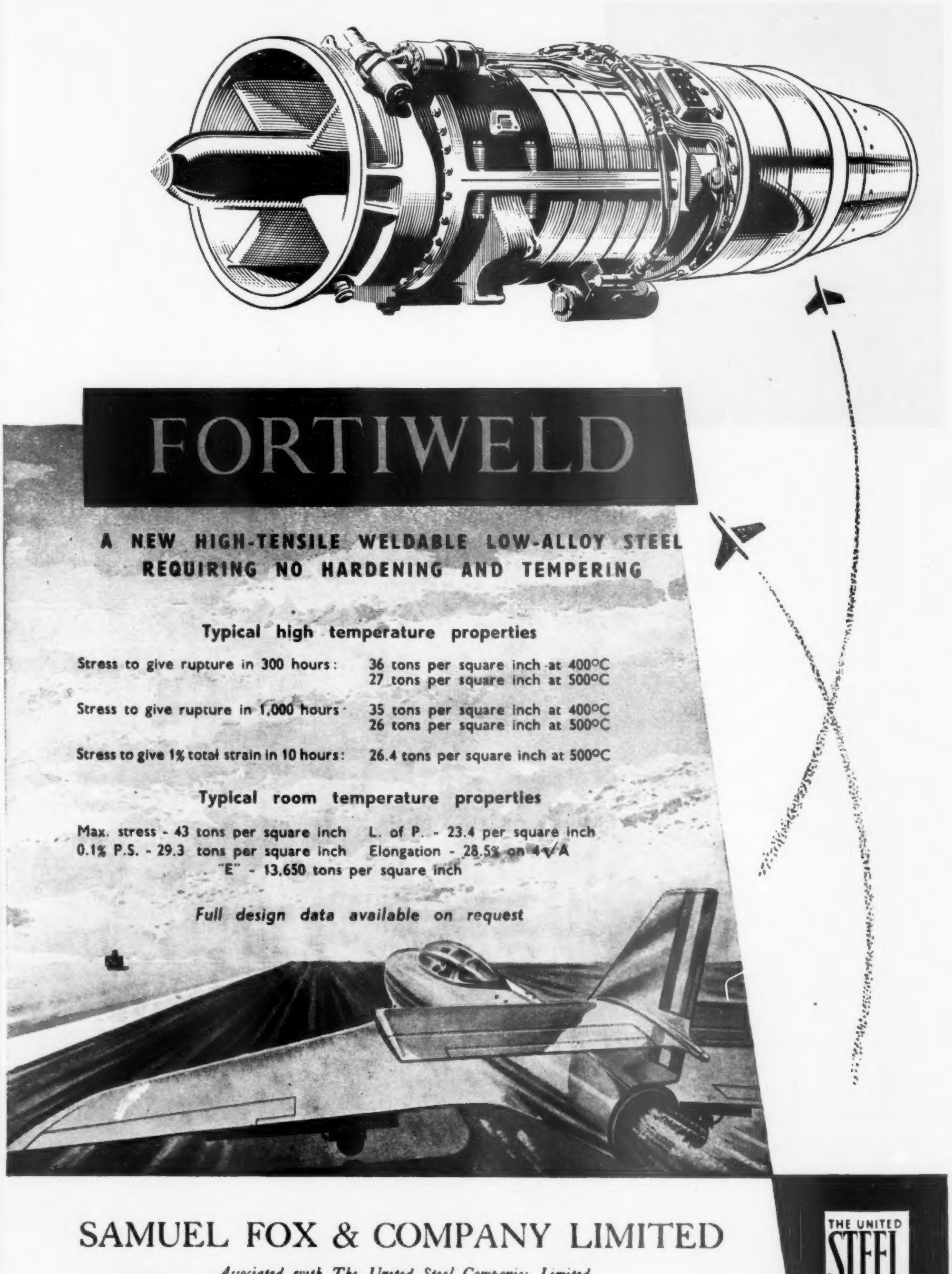
FORTIWELD
A NEW HIGH-TENSILE WELDABLE LOW-ALLOY STEEL
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Typical high temperature properties
Stress to give rupture in 300 hours: 36 tons per square inch at 400°C
27 tons per square inch at 500°C
Stress to give rupture in 1,000 hours: 35 tons per square inch at 400°C
26 tons per square inch at 500°C
Stress to give 1% total strain in 10 hours: 26.4 tons per square inch at 500°C
Typical room temperature properties
Max. stress - 43 tons per square inch L. of P. - 23.4 per square inch
0.1% P.S. - 29.3 tons per square inch Elongation - 28.5% on 4√A
"E" - 13,650 tons per square inch
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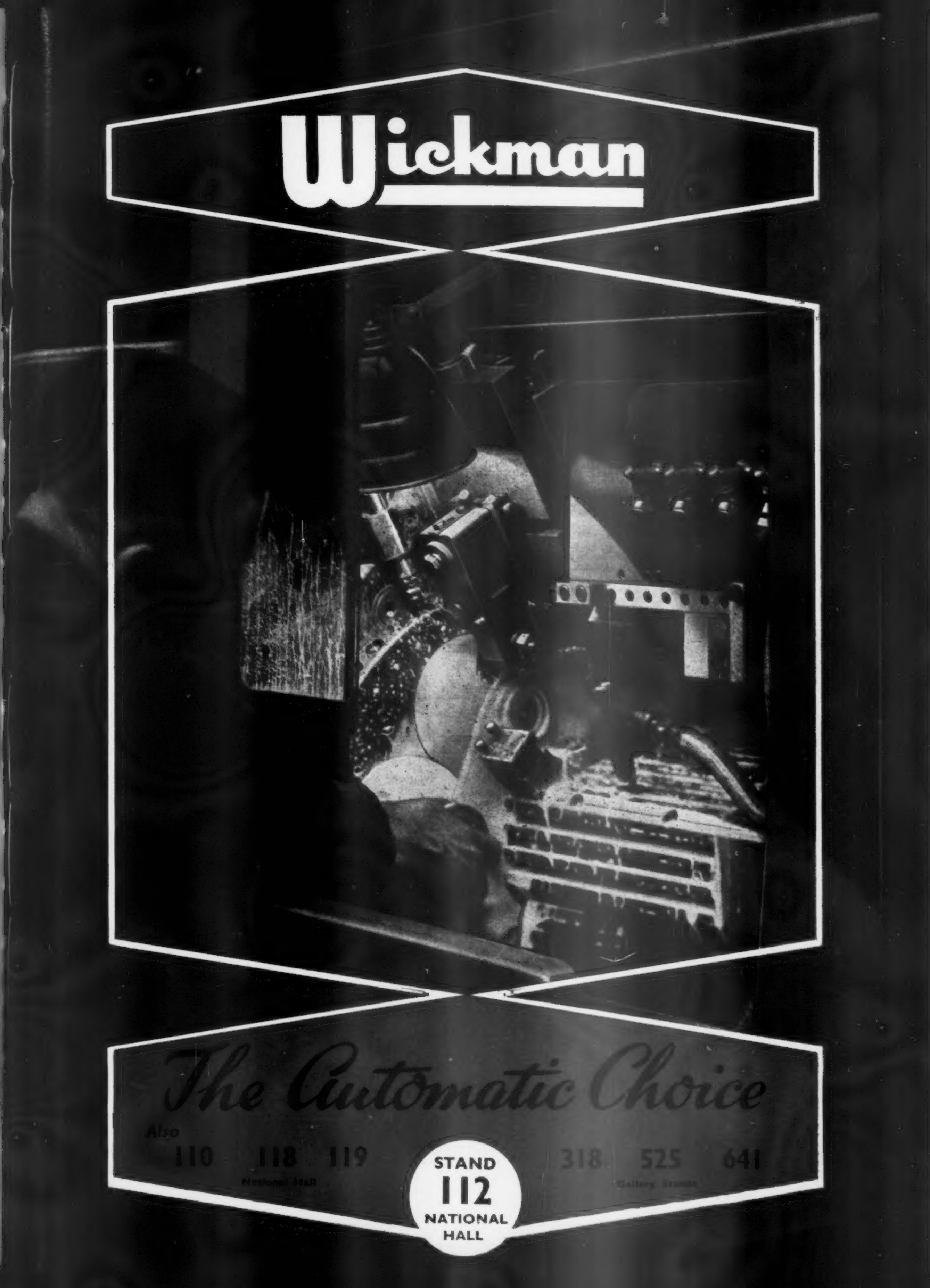
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112
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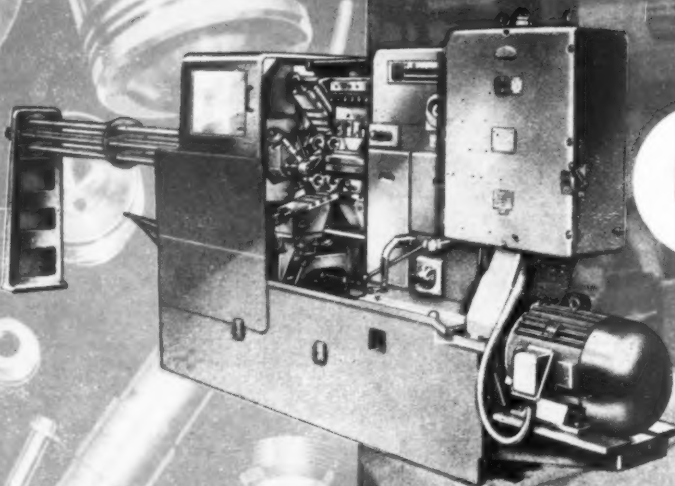
Bar Machines



1"-6

Bar capacity —	
round	1" (25·4 mm.)
hexagon, across flats ...	55/64" (21·8 mm.)
square, across flats ...	45/64" (17·8 mm.)
Bar feed stroke	0 — 5" (0 — 127 mm.)
Spindle speed in 22 steps, r.p.m. (Normal machine)...	347 — 2510
Spindle speed in 24 steps, r.p.m. (High speed machine)	347 — 3030
Range of cycle times	2 — 133 secs.
Motor h.p. and speed r.p.m.	15 × 1460
Overall dimensions	3' 7" × 19' 5" (1092 × 5918 mm.)
Approx. nett weight	4 tons 12 cwt. (4674 Kg.)

2"-6

Bar capacity —	
round	2" (50 mm.)
hexagon, across flats ...	1.11/16" (44 mm.)
square, across flats ...	1⅜" (36 mm.)
Bar feed stroke	½" — 10" (12 — 254 mm.)
Feed stroke on main tool block	0 — 5" (0 — 127 mm.)
Feed stroke on independent slides	0 — 5" (0 — 127 mm.)
Spindle speed range in 24 steps, r.p.m.	111 — 1302
Range of cycle times	7 — [illegible] secs.
Motor h.p. and speed r.p.m.	25 × 1450
Overall dimensions	4' 10" × 21' 10" (1470 × 6668 mm.)
Approx. nett weight	10 tons (10,150 Kgs.)

2⅝"-6

Bar capacity —	
round	2⅝" (67 mm.)
hexagon across flats ...	2¼" (57 mm.)
square across flats ...	1.27/32" (47 mm.)
Bar feed stroke	0 — 5" (0 — 127 mm.)
Feed stroke on main tool block	0 — 5" (0 — 127 mm.)
Spindle speed range in 24 steps, r.p.m.	80 — 1000
Range of cycle times	7·1 — 922 secs.
Motor h.p. and speed r.p.m.	40 × 1425
Overall dimensions	4' 11" × 20' 6" (1499 × 6148 mm.)
Approx. nett weight	13 tons (13208 Kgs.)

ge . . .

LE AUTOMATICS

whose daily concern looking to automatic recedented demands

Wickman range of nearly twenty years' service to the metal- e and lasting solution ds, and the handicap

chines of their class, mentary attachments, tion production up to for castings, forgings

utosetting mechanism simple adjustment of changing cams. The es and permits fast nic machining of small

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duction of repetition ed at the International strating under actual

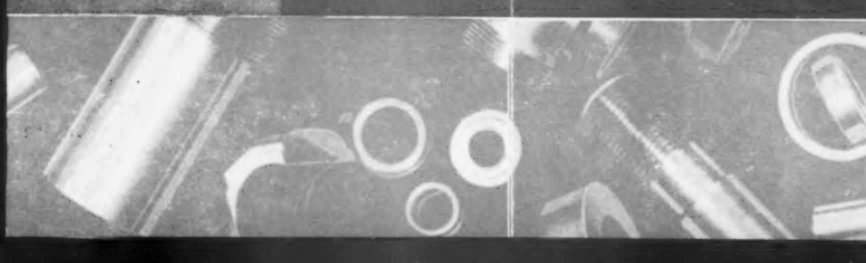
Bar capacity — round	3½" (89 mm.)
Bar feed stroke	0 — 5" (0 — 127 mm.)
Feed stroke on main tool block	0 — 5" (0 — 127 mm.)
Spindle speed range in 24 steps, r.p.m.	80 — 800
Range of cycle times	9 — 923 secs.
Motor h.p. and speed r.p.m.	40 × 1425
Overall dimensions	4' 11" × 20' 8" (1499 × 6148 mm.)
Approx. nett weight	13 tons (13208 Kgs.)

Chucking Machines

Maximum swing ...	6.11/1
Feed stroke on main tool block	0 — 5"
Feed stroke on independent slides	0 — 5"
Spindle speed range in 32 steps, r.p.m.	51 — 8
(alternative)	78 —
Range of cycle times ...	10·6 —
(alternative)	[illegible]
Motor h.p. and speed r.p.m.	20 × 9
(alternative)	25 × 1
Overall dimensions ...	4' 10" (1473
Approx. nett weight	9 tons (9144 k

Maximum swing	7.5/16
Feed stroke on main tool block	0 — 5
Feed stroke on independent slides	0 — 5"
Spindle speed range in 24 steps, r.p.m.	51 — 6
(alternative)	77 —
Range of cycle times ...	10·9 —
(alternative)	7·1 —
Motor h.p. and speed r.p.m.	30 × 9
(alternative)	40 ×
Overall dimensions	5' 1" (1543
Approx. nett weight	11¼ to (11684

Maximum swing	9" (22
Feed stroke on main tool block	0 — 5"
Feed stroke on independent slides	0 — 5"
Spindle speed range in 24 steps, r.p.m.	28 —
(alternative)	43 —
Range of cycle times ...	17·7 —
(alternative)	13·8 —
Motor h.p. and speed r.p.m.	30 ×
(alternative)	40 ×
Overall dimensions	5' 1" (1543
Approx. nett weight	11¼ to (11430



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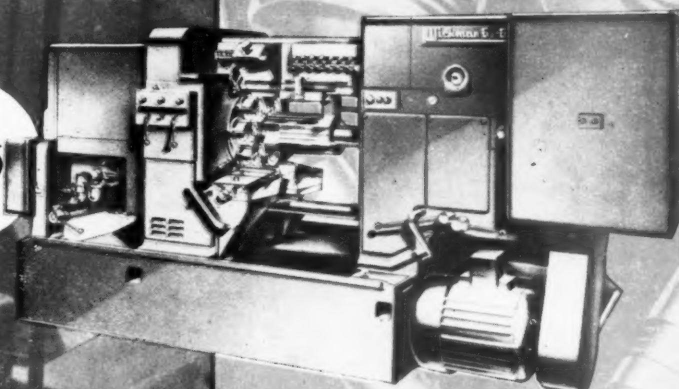
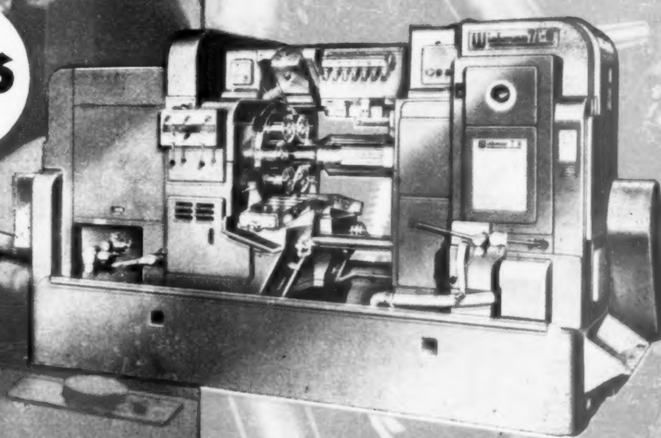
6 5/8"-6



... ...	6.11/16" (170 mm.)
...l block	0 — 5" (0 — 127 mm.)
...pendent	
... ...	0 — 5" (0 — 127 mm.)
... in 32	
... ...	51 — 862
...rnative)	78 — 1302
...	10·6 — 1297 secs.
...rnative)	7·0 — 859 secs.
... r.p.m.	20 × 960
...rnative)	25 × 1460
	4' 10" × 13' 8" (1473 × 4162 mm.)
... ...	9 tons (9144 Kgs.)

7 1/4"-6



... ...	7.5/16" (185 mm.)
...l block	0 — 5" (0 — 127 mm.)
...pendent	
... ...	0 — 5" (0 — 127 mm.)
... in 24	
... ...	51 — 653
...rnative)	77 — 1004
...	10·9 — 1408 secs.
...rnative)	7·1 — 922 secs.
... r.p.m.	30 × 950
...rnative)	40 × 1460
... ...	5' 1" × 14' 4" (1543 × 4370 mm.)
... ...	11½ tons (11684 Kgs.)

9"-4

... ...	9" (228 mm.)
...l block	0 — 5" (0 — 127 mm.)
...pendent	
... ...	0 — 5" (0 — 127 mm.)
... in 24	
... ...	28 — 363
...rnative)	43 — 554
...	17·7 — 1968 secs.
...rnative)	13·8 — 1315 secs.
... r.p.m.	30 × 950
...rnative)	40 × 1430
... ...	5' 1" × 14' 4" (1543 × 4370 mm.)
... ...	11¼ tons (11430 Kgs.)

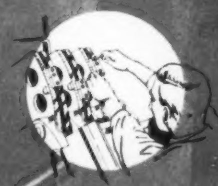
Five Reasons Why

more and more producers of repetitio
turned parts choose Wickman

1 Accuracy

Few types of machine tools are produced to closer toler ances than the Wickman Multi-Spindle Automatic, and stringen inspection tests are carried out to ensure that every significa element of every machine completely meets the high standard laid down.

Inherently accurate themselves, they therefore produc accurately, according to users in fact, " more accurately tha most machines of their kind."

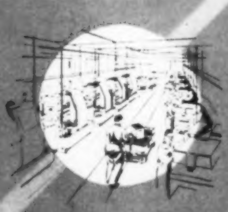


2 Quick Set Up

In the continual search for higher and yet higher outpu quick set-up makes its contribution. Production shops con cerned with medium to long batch production, therefore, loo for simple change-over from job to job, and with the Wickma they get it. Incorporation of the Wickman auto-setting mech anisms enables tool feed strokes and bar feed to be set in matter of minutes without changing cams, and because too holders are interchangeable between many stations an between machines in the series, their selection and applicatio are simplified.

3 Tooling Flexibility

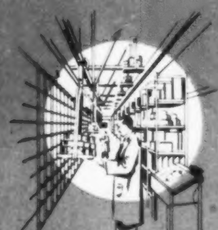
Independent tool slides mean unrestricted tooling pos sibilities. Five independent end-working slides made up b two integral upper independent slides, the centre block, an two auxiliary slides applicable to the centre block on si spindle machines, plus independently operated cross slide provide for every possible tooling contingency.



4 Dependability

The record of Wickman autos in the field is a proud on Years of single- and double-shift duty in this country an abroad, frequently with semi-skilled labour, and always unde high production conditions, testifies to their high quality an rugged construction.

First-hand experience of the daily treatment accorded production machine tools has enabled Wickman designers build into vital parts, strength and robustness far beyond th ever likely to be required.



5 Service

While appeals for urgent service are infrequent, fatigu sometimes takes its toll. When it does Wickman service ge things moving and quickly.

The best testimony to the quality of Wickman service provided by existing users, to whom more than half the outp of new machines is regularly delivered in the form of repe orders.

repetition

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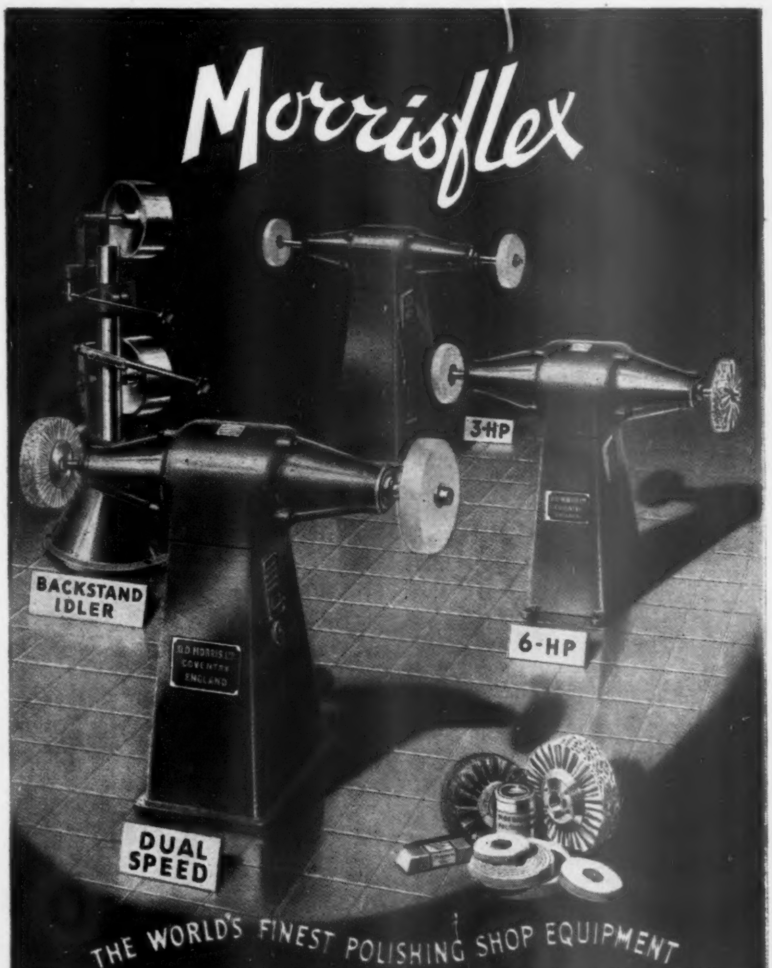
MACHINE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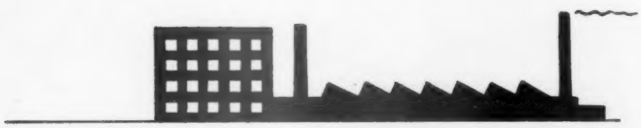

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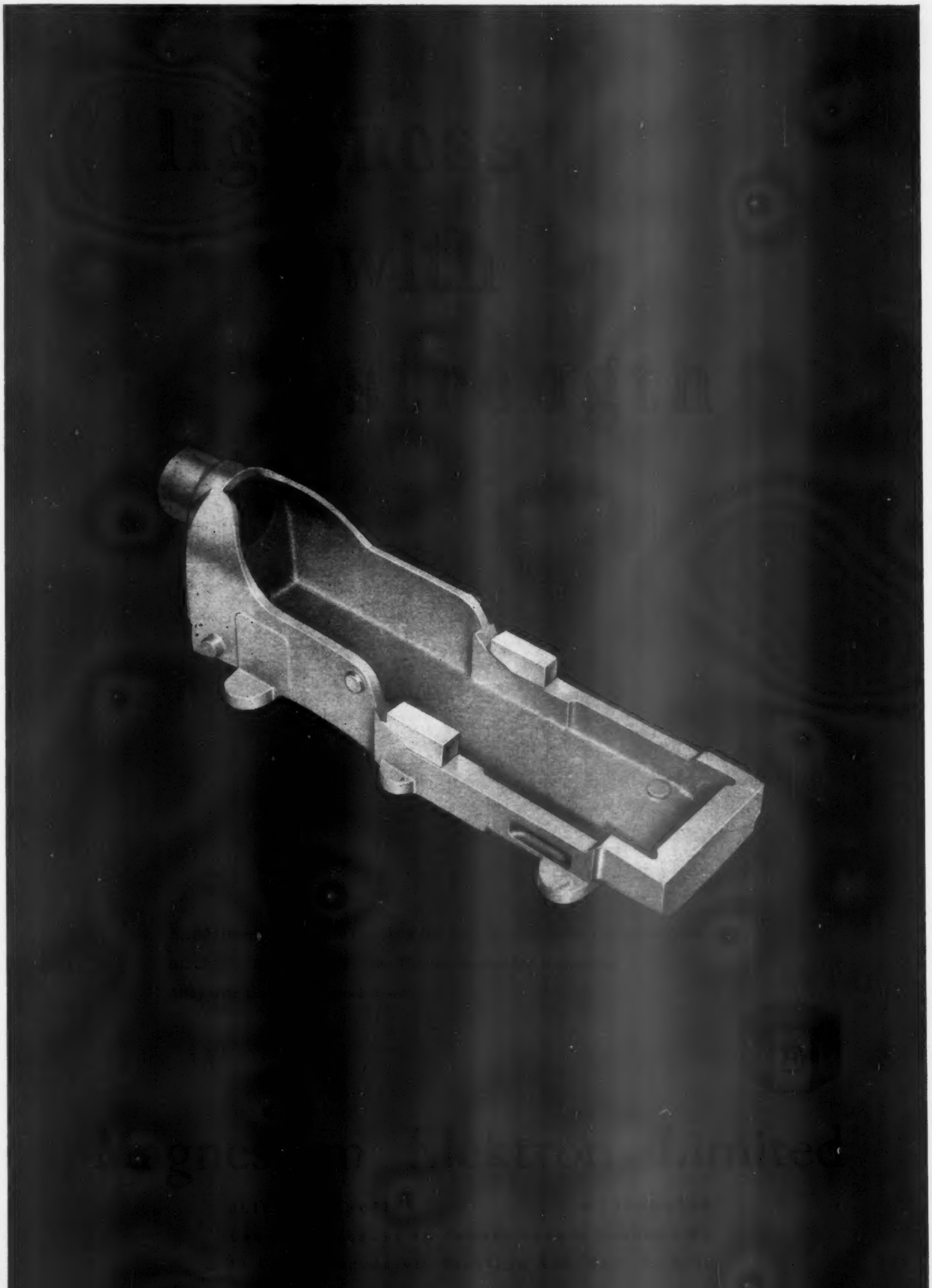


The Institution of Production Engineers Journal

VOL. 35 NO. 5 MAY, 1956

"Investing in Success"

by E. C. GORDON-ENGLAND, M.I.Prod.E., F.R.Ae.S.

Vice-Chairman Production Exhibition & Conference Advisory Committee.

SIR Walter Puckey described the first Production Exhibition and Conference which was held in 1954 as, "A new type of Exhibition". The experiment was conceded, generally, to have been a triumphant success and exceedingly well timed, and the view was expressed on all sides that the Exhibition and Conference should be repeated biennially, thus becoming a regular feature of Britain's programme of industrial exhibitions.

This second Exhibition and Conference should prove to be of even greater value to those engaged in the direction and management of production in Great Britain than its splendid prototype, for it would be hard to point to a time in British industrial life when there was more need for inspiration and a refreshing call to challenge existing practices and raise the productivity of the British people to far higher levels.

Our authorities have called "Wolf! Wolf!" so frequently in the post-war years that today there is a complacency abroad that is almost frightening to those who understand the truly desperate economic straits to which the country has been brought.

The purpose of those who have devoted so much of their time, thought and energy to the organising of the forthcoming Exhibition and Conference has been to inspire all who attend it with a determination to "invest in success", for it is only by making that kind of investment that our hope lies of putting an end to the frequently recurring and increasingly grave economic crises from which this country suffers.

Mr. R. A. Butler, in his now famous speech, coined the phrase, "investing in success", and claimed that we could, by right thinking and action, double our standard of living within the next 25 years. The economic set-back that has overtaken us since he made that statement in no way disproves his thesis ; this crisis may well be the beginning of our realisation of his objective, if we will bestir ourselves.

The Advisory Committee, set up by the Institution and which includes representatives from B.P.C., B.S.I., D.S.I.R., T.U.C., and which was formed to be the co-ordinating influence in the affairs of the Exhibition and Conference, accepted at its first meeting on 19th July, 1955, Mr. Butler's challenge and adopted his phrase, "investing in success" as the theme for both the Exhibition and the Conference.

Here is perhaps the appropriate place to pay our tribute to all those who have given so freely of their precious time and energy and, above all, deep thought to ensuring that those who attend the Exhibition and the Conference will find themselves becoming embued not only with a desire to " invest in success " but the determination to achieve success. How the Advisory Committee have set about this task will become apparent to those who study the programme of sessions which, we believe, will be greatly appreciated by the visitors.

Much careful thought has been given to ensuring that the theme of the Conference will unfold in an orderly and progressive manner, and that the contributions of each speaker, and those taking part in the discussions will, in sum, make a positive contribution to production engineers all over the country being inspired to " invest in success " so far as their personal contribution to solving the problems of greater productivity is concerned.

The Exhibition is not a " selling show ". Each exhibit will be an example of improvements in productivity. Each exhibitor will show how he has improved his own productivity or how the application of his ideas or processes can improve the productivity in other organisations. Thus the Exhibition is highly selective.

So pressing and so real is the need for all engaged in the ranks of industry to take a new look at the problems of achieving greatly improved productivity, in their own interests as well as that of the country, that there is an inescapable duty on the shoulders of all in the ranks of management in industry to make it possible for all grades who form the working unit to visit this Exhibition and Conference.

That duty will have been faithfully discharged if, throughout the duration of the Exhibition the aisles and avenues are packed with the " people in industry ", and each session of the Conference is packed to the doors.

Every effort has been made by the organisers to provide the stuff from which inspiration can be drawn, but that inspiration needs people present for its manifestation. If every member of the Institution of Production Engineers ensures that as many under his direction as possible will visit the Exhibition and attend the appropriate sessions of the Conference he will, indeed, be " investing in success ".

Investment indicates the wise expenditure of deep thought followed by vigorous and appropriate action at the right time.

Now is the right time!

PRIDE IN WORKMANSHIP: TODAY'S CHALLENGE

by SIR GORDON RUSSELL, C.B.E., R.D.I.

Presented to the Institution in London, 7th March, 1956.

Sir Gordon Russell is a manufacturer of furniture which is widely known, he is an industrial designer who in 1940 was awarded the distinction of Royal Designer for Industry, and he is a craftsman with a considerable range of skills. He was an original member of the Council of Industrial Design in 1944, and was appointed its Director in 1947.

He has travelled extensively in Europe and America studying design and is in touch with many of the best-known designers in a number of countries. He has also written, lectured and broadcast for many years.

Sir Gordon Russell

ANYONE who has visited a number of factories and workshops must have been struck by the astonishing differences in atmosphere which they present. Sometimes it seems as if friendliness and interest in the job go up in inverse ratio to the size. The craftsman working by himself or with one or two assistants nearly always considers the quality of the work above everything. Occasionally one comes across a small firm where the zest for turning out a really good job appears to triumph over totally inadequate equipment. It is more likely to be in a larger unit where one runs into the unhelpful "couldn't care less" attitude, though there are plenty of examples of large firms where the equipment is first-rate and the atmosphere all it should be. Nor is it only in old-established firms in which a great tradition has been built up that one finds pride in workmanship. Sometimes it seems to grow up overnight, as it were, especially in any branch of industry which arouses great popular interest.

Let me give an example. Transport from the earliest times has interested men, who love to be able to get about and to move goods from place to place. Indeed, a reasonable standard of civilization depends on it. It has survived a series of revolutions from the invention of the wheel onwards which have in many cases involved a fresh start. Ships, boats, carts, carriages, sedan chairs, sleighs, saddles and harness, howdahs, stage coaches, railway engines and rolling stock, velocipedes, bicycles, motor cars, aeroplanes — all have demanded high quality in workmanship in order to function smoothly and achieve safety. Scamped work could not be tolerated. This is a reasonable commonsense point of view which deserves and earns respect. But for many centuries such things have appealed not only to men's heads, but to men's hearts so strongly as to be thought of as feminine. Who has not seen a tough man caress the hull of a boat with his hand and say, with hardly suppressed emotion, "My word, she's a beauty!"

Have we some key here to the possibility of recapturing in other fields that pride in workmanship which the craftsman has and the machine-minder is in danger of losing? This is a problem which has given many headaches to production engineers. I would like to suggest that the ordinary man's interest in design, implicit in the exclamation "My word, she's a beauty!", is a fact which should have far more weight when a lack of interest in the job is under discussion.

The Meaning of "Design"

I believe that the word "design" has been bedevilled by all sorts of "arty" considerations until, to many people, it has acquired an unrealistic flavour. This is most unfortunate. According to the Concise Oxford Dictionary, to design means "to contrive, to plan, to conceive a mental plan for, to draw the plan of (building etc. to be executed by others)." That is clear enough. The great difference between hand and machine production is that in the former, broadly speaking, one man is responsible from beginning to end and in most cases the design can be varied even during production. The potter throwing his clay on the wheel can achieve a greater or lesser sensitivity in the form of his pot according to what kind of artist he is. Even an unimaginative man working in a well-known and respected tradition can produce articles of real beauty. But machine production calls for the subdivision of processes and to achieve this nothing less than a complete set of blueprints is essential before any work is put in hand. When the plan has crystallised alterations can only be made at the cost of considerable disorganisation and great expense.

I do not wish to infer that machine production is necessarily superior or inferior to hand production, but that it needs a fundamentally different approach. For many centuries some heavy work has been done by machines: by the 17th century, for instance, the Dutch had become so expert in the use of windmills for pumping water so as to drain their flat country that they had already applied the same source of power to the sawing of wood. They also carried the process further and invented a machine which produced intricate wavy mouldings for cabinets and picture frames in dense woods such as ebony. These two aspects of the use of the machine were developed side by side. The cutting out of intensely hard physical labour was always a prime objective. The making of accurate repetitive patterns must have followed it closely. But both these still left the craftsman substantially in charge as far as the finished product was concerned. It was not long, however, before the extreme accuracy of which the machine is capable was seized upon in order to make assembly take the place of fitting. The development of the clock, calling for ever greater accuracy in performance, was astonishingly rapid in England in the 18th century. Lewis Mumford describes it as the master machine of the industrial revolution. This is a most apt description, for the clockmaker not only called on the pooled experience of many generations of skilled millwrights who worked mostly in wood. By translating their knowledge to metal, he set standards for other machines — but also by enabling the use of the machines to be synchronised, he made it possible to link up many diverse operations.

The Importance of Drawings

The new method made it essential to arrange the operations in their correct sequence and time them accurately. For this to be possible complete drawings are necessary. This is a matter on which you, as production engineers, are extremely well informed. I merely state it in order to emphasise my belief that drawings for machine production ought to be the concrete embodiment of a serious attempt to gain the interest of the maker, the seller and the customer. I know full well that this is an immensely difficult job to set out to do, because although we do not use working drawings, it is in fact the most vital part of the kind of work we do in the Council of Industrial Design. How often is it attempted in industry? And if it is not attempted how, under the conditions of today, do you suppose pride in workmanship is a realisable goal?

The Inference of Automation

The astonishing specialisation created by machine conditions was underlined as early as 1776, when Adam Smith pointed out in "Wealth of Nations" that there were apparently as many as eighteen distinct operations involved in the making of a pin. That the endless repetition of one small operation leads to lack of interest in the resulting job is no doubt true, at least as far as workers with any imagination are concerned. But to an increasing extent such operations are being taken over by more fully automatic machines, which give opportunities for still higher pay and shorter hours. Yet this tendency has not led to a noticeably greater feeling of pride in workmanship, although it ought theoretically to release workers for more responsible and interesting work. I believe the root cause is that the operative feels he can no longer have any influence on the design of the article for which he is asked to produce some small component.

Basically it is the same problem as that which faces democracy. How can one keep up interest in the dull workaday affairs of the world, the sense of mission which is created by some spectacular challenge? To those who fought for the right to vote it would have seemed inconceivable that many would not take the trouble to go to the poll. In all departments of life we see today the breakdowns caused by the growth of centralised authority, the replacement of the small personal community by the large impersonal group, whose unknown leaders become "They". Some nations believe that the answer is to dramatise an omnipotent führer. But our instinct leads us to wish to take the harder and more efficient road.

In industry, as elsewhere, I believe we must build up new ways of making contact with new forms of education, so that the worker may see clearly what is his own personal place in the scheme of things. If a thing is worth making at all it should come naturally to the average man to take an interest in making it. If he does not, something is wrong and the firm, being the more powerful, should start with the assumption that the fault lies with it. Far too many employers and trades unions still think that higher pay is the only way to attack industrial trouble. I do not think interest in the job—pride in workmanship—should be regarded as a substitute for good wages, but as a solid buttress to their permanency.

The 19th century description of employees as "hands" encouraged a certain type of employer in the past to say with gusto, when an improvement was

suggested: "You are not paid to think!" But to tackle the immense problems of today we not only need the pooled experience of all who can use their heads, but we need to touch their hearts.

A Valuable Experiment

During the War a valuable experiment was made in aircraft factories. Pilots from the R.A.F. visited them and spoke to the workers, telling them exactly what happened in action to the 'planes they made. One faulty rivet or imperfect weld might lead to the loss of the whole irreplaceable crew of brave men and so enable the enemy to throw all his weight on the other crews. I am told that the result of these talks was electric. Many operatives had not fully understood their responsibility, although they had been doing a good job and working appallingly long hours. They went back to their benches with a new zest. Could not the same sort of thing be done in peacetime? Of course, the situation is not so tense and dramatic. Yet there are many operatives—and indeed executives—of firms making household equipment who would benefit, say, from a talk by a highly intelligent housewife who had used the equipment in her own home. There is in fact too little contact generally between the maker and user; as there is between management and the man at the bench. No doubt I shall be told that costs are already so high that any further addition in the form of education would prove ruinous. But does any firm really know the cost of high labour turnover, the cost of threatened and actual strikes, perhaps in a trade supplying goods or services which at first seem remote?

Many people are inclined to talk as if a thing made by hand is necessarily superior to one made by machine. Certainly this would not seem to be the case, although the characteristics, as I have tried to show, are often very different. No one in his senses could describe an aeroplane engine as inferior. It is made to limits of tolerance which would have seemed fantastic a few years back and this gives it the beauty of precision. And it is made of materials so rigidly specified and so rigorously tested for suitability that it would have seemed like a highly-organised laboratory experiment even a couple of decades ago. Listen to this description of engine building written by Richard Reynolds in October, 1760:

> "Began this day to scour the bore of a great cylinder of a fire engine for drawing the water from the coal pit at Elphinstone, of a bore twenty-eight inches across, and in length nine feet, the same being cast of brass after much discouragement, and the spoiling of three before, which made us of much doubt if we could ever succeed in a task of such great magnitude; but being by reason of the extremity to which the proprietors of the pit were at, having to employ more than fifty horses to discharge the water thereof much urged to persevere, we give great gratitude to Almighty God, who hath brought us through such fiery tribulations to an efficient termination of our ardous labors.
>
> "Having hewed two balks of deal to a suitable shape for the cylinder to lie therein solidly on the earth in the yard, a plumber was procured to cast a lump of lead of about three hundred weight, which being cast in the cylinder, with a dike of plank and putty either side, did make it of a curve to suit the circumference, by which the scouring was much expedited.
>
> "I then fashioned two iron bars to go around the lead, whereby ropes might be tied, by which the lead might be pulled to and fro by six sturdy and nimble men harnessed to each rope, and by smearing the cylinder with emery and train oil through which the lead was pulled, the circumference of the cylinder on which the lead lay was presently made of a superior smoothness; after which the cylinder being turned a little, and that part made smooth, and so on, until with exquisite pains and much labor the whole circumference was scoured to such a degree of roundness, as to make the longest way across less than the thickness of my little finger greater than the shortest way; which was a matter of much pleasure to me, as being the best that we so far had any knowledge of; but I was busy casting about in my mind for means as to how it might be in future made better, and I reckoned, for one thing, that I would so fashion the iron bars to which the ropes were tied, that they might be laid in the cylinder, and the lead cast on them, and so fasten them firmly."

Here is a description of the toughest kind of manual work carried on without complaint, indeed with every apparent sign of interest for days on end. The resulting accuracy, although to us it seems farcical, was to them a great advance on previous attempts of the kind and, therefore, the men engaged had all the zest of the pioneer in achieving a new standard in workmanship. And as they were men of sincere religious beliefs they were able the more clearly to see their own place in the scheme of things, with humility and dignity, and without trace of the frustration which is so common in our more luxurious age.

Is it perhaps true that our great advances in techniques and materials have not often been matched by a corresponding improvement in design? By this I mean design in its fullest sense. Competent engineering design is the first essential, but it is not enough. We need also far more attention to the aesthetic, as distinct from the purely practical, side of design. We need, for instance, much greater discrimination between beautiful and ugly shapes though both may be equally effective. We need a more highly trained sense of colour, for poor colours cost just as much to buy and to apply as good ones. We need a greater awareness of the use of texture and pattern. In engineering these have important practical uses. The engine turning on a watch-case, for instance, is an efficient way of hiding the inevitable scratches. And the colouring of pipes can make servicing more rapid and certain. But there is no reason at all why such treatments should not be so

designed as to bring out the full beauty of the form of the object. How often does one find that aim has been achieved ? If lettering is necessary why not good legible lettering related to the space in which it is put ? If the article is, let us say, a machine which embodies meters, gauges, dials, motors, etc., made by different firms, is there no way of co-ordinating their design ? Unless all the makers have similar design standards the resulting machine is bound to lack the sense of harmony for which we so often look in vain. And it is just that sense of harmony — that perfect fitness for purpose — which lights up the eyes of the artist — and at heart most engineers are artists — and leads him to exclaim " My word, she's a beauty !".

It is because I agree so wholeheartedly with Eric Gill when he said that the artist is not a particular kind of man but every man is a particular kind of artist, that I feel far more could be done through design to create more interest in the job and greater pride in workmanship.

Improving Engineering Design

How could we set about it ? There seem to me to be two ways of improving engineering design.

The first, and I think the more important, is to find time to create an interest in aesthetics in the engineering student, draughtsman and designer. This is not easy, for he, like the rest of us, normally comes from a background with little beauty, the curriculum is already crowded and the tendency is for it to become more so. And when he gets into industry he is generally working against time. But could not a great deal be done by improving the student's background, whilst he is learning his job? How many canteens, hostels, common rooms, waiting rooms and so on can you think of which reach any kind of reasonable design standard ? The same applies in any industrial job, as a rule. And a programme of lectures on design subjects has often proved to be popular. The visits of apprentices to the Leonardo da Vinci exhibition at the Royal Academy was most certainly a step in the right direction. It must have brought home to many people the astonishing fact that a great artist can also be a great engineer! How can one expect engineers to design good shapes if they don't have any good shapes around them ? Of course, there are always exceptional people who can ignore such grave disadvantages, but they are rare indeed. And you would probably find that they took a keen interest in ballet, drama or painting and got their stimulation that way. But stimulation in some form the artist-engineer must have, and it isn't easy to come by in the average British industrial town.

The " Artist-Engineer "

By the way don't let us boggle at the use of the term " artist-engineer ". It was used proudly by some of the greatest English locomotive engineers of the 19th century, who cannot be regarded as a soft lot, by any stretch of imagination.

It was F. W. Webb, superintendent of the London and North Eastern Railways in the 1890's, who told his directors they could have their locomotives painted any colour they pleased so long as it was black, a saying adopted by Henry Ford for cars. But Webb's black was of a subtle purplish hue. Patrick Stirling, designer of the famous eight-foot single driving wheel locomotives of the Great Northern Railway, was a cantankerous character who valued the appearance of his engines even above their performance, which with light trains was remarkable. When David Joy suggested to him mechanical improvements in the running gear necessitating external changes at the cross-head, Stirling shouted that he " would'na spile the appearance of ma grand engine with the likes of all that machinery outside of her." British designers of locomotives have from the first achieved eminently neat and shipshape exteriors, but seldom at the price of refusing to consider improvements. I am glad to learn that the ugly streamlined covers which made their appearance on railway engines before the War are now being discarded because they make servicing more difficult without any noticeable effect on speed. They were really poor examples of styling, out of an adjacent stable to " tavern-cars ".

I think it is extremely important to remember that to try to design better products as an end in itself seldom works. *To design better products it is necessary to lead a more civilised life.* The products will inevitably be better if the designer is more sensitively aware of his surroundings. Few of us will ever measure up to Leonardo da Vinci's standards, but I am convinced that the good designer — and I am thinking here especially of the engineer — should be a good all-round man, insofar as the term can be used in an age of appalling specialisation. He should not be the prosaically practical bigot who says " I could not see how music could possibly lead to my earning more money, so I cut it right out ! " Rather he should aim to develop an interest in subjects as diverse as possible, so as to become a well-balanced and harmonious personality.

Importance of Spiritual Values

Just after the first war an American came to England who was dubbed by the press the Kitchen Range King of America. Asked what struck him most about England, he said that he was utterly dumbfounded to see how much time was being wasted in growing flowers, when the country had been so impoverished. He did not realise that in the end spiritual values must always be more powerful than material ones, the only ones he understood. The thought of barbarians trampling a wood of English bluebells played its part in breaking many a desperate German attack. We are, perhaps, less successful in coping with our own barbarians!

Many firms actively support such ideas of wider education which certainly ought not to end when the student has finished his period of training. It is sometimes highly desirable to bring in a consultant industrial designer to work with the engineer from the inception of a project. It is seldom of the slightest use to bring him in at the end. Engineers are sometimes unduly sensitive about accepting this

kind of help, which they are apt to feel is not so much a reflection on their professional ability as on their taste. Everyone, it seems, is supposed to have good taste, yet no one imagines that a man could drive a motor-car, wash the baby or cook a dinner without a bit of instruction!

A Fruitful Partnership

The industrial designer and the engineer have much to learn from each other. The essential thing in any fruitful partnership is that the parties should not be utterly incompatible. I have known some very good designs come to fruition in this way. But this has always been when some member of the Board took an intelligent interest in the affair, and steered the team round anxious corners. Usually he acted as chairman of a small design group, which included both production and sales. The designer must not expect to have the moon handed to him on a plate and the engineer must be prepared to listen to a point of view which may be strange to him. What outside help can the firm call on? This is exactly where the Council of Industrial Design comes in. The Council, which was set up by the Coalition Government in 1944, is not an executive body. It is purely an advisory and publicity organisation. It has no powers to tell industry to do this or not to do that; it has no powers to ban bad design, nor, of course, actually to sell the good, though it is always our hope that by drawing attention to well designed things their makers will prosper and others will follow their example. We would deplore any form of dictation, not only because of the natural British distaste for it, but because it might quickly lead to a sterile orthodoxy and an official taste. This is the last thing we want. There must be room in any society for a wide variety of tastes and styles, though each should be good of its kind.

The Council treats the problem of raising standards of design in industry broadly as a question of supply and demand. We believe that a more critical public is necessary to secure a real improvement, but also that the public cannot demand better things until it has a chance to see them, that is until manufacturers produce them and retailers show them.

The Council's services to industry include advice on design policy but not, of course, actual designs for products; advice on choice of designers for particular projects by means of recommendations from a comprehensive Record of Designers; organising design competitions and exhibitions for manufacturers and designers; publication of the successful monthly magazine "Design", which reviews design developments in Britain and overseas and comments critically and constructively on products, materials and processes; and, what is now one of the most important of all the Council's activities, selection of products for "Design" Review, a photographic and sample record of good current designs in a wide range of consumer goods, and therefrom for the Council's permanent but constantly changing exhibition of well designed British goods, The Design Centre for British Industries, and other exhibitions both at home and abroad.

It has long been the Council's ambition to organise such a permanent exhibition as The Design Centre—which is to be opened at 28 Haymarket by H.R.H. The Duke of Edinburgh on 26th April — for there is no better way of improving design than for manufacturers, buyers and the public to be able to study in one place the best that is available. It will offer manufacturers whose goods qualify for inclusion an opportunity for valuable new promotion at modest cost for the sale of goods at home and overseas. It will demonstrate to those whose goods are not acceptable the qualities which their products lack and they will be able to seek immediate advice on means of improving them. We shall welcome visits by groups of all kinds and I hope that manufacturers and retailers may think it worthwhile sending their staff and workers, for I am convinced that it is only by increasing the interest of all concerned with the manufacture and sale of goods in high standards of materials and workmanship, and especially of design, that an improvement can be achieved and the continuing prosperity of our nation be assured.

I do not for one moment expect everyone to agree with me, but I hope that I shall provoke a stimulating discussion. It is because I am proud of British engineering products that I have dared to be critical when I feel that many are less good than they might be. If you feel there is something in my criticism, may I ask you whether you feel everything possible is being done in your own works to stimulate interest in Pride in Workmanship?

(A Report of the Meeting appears overleaf)

REPORT OF THE MEETING

at The Royal Institution, London

Wednesday, 7th March, 1956.

In the Chair: Mr. E. W. Hancock, M.B.E., President-Elect.

THE **Chairman** said that he counted it a great privilege to preside over the meeting at which the George Bray Memorial Lecture was to be delivered. The Lecture was established in 1952 when the directors of George Bray and Company donated £500 to the Institution to be invested so that the interest each year would finance the presentation of a Memorial Lecture, in remembrance of Colonel George Bray, who made a continuous contribution to the work of the Institution during his lifetime. He was at one time the President of the Yorkshire Section.

The terms of reference for the Memorial Lecture stipulated that the subject selected should be " not traditionally associated with production engineering." The Institution must broaden its base if special knowledge and techniques were to be adequately applied, and therefore it was a good thing once a year to " sit back ", as it were, and open wide " the windows " to let in some fresh air, rather than to remain with " noses to the grindstone " discussing metal removal and day-to-day production engineering.

Sir Gordon Russell, he felt sure, would not object to the use of simple words in saying that he was associated with the manufacture of furniture, and that association was widely known.

The Institution was privileged to have Sir Gordon Russell to lecture to its members and visitors on such an important subject as " Pride in Workmanship : Today's Challenge."

(*Sir Gordon Russell then delivered his Paper, which appears on pages* 281/285.)

Mr. B. H. Dyson (*Chairman of the Institution's Research Committee*) who opened the discussion, said it was easy to assume that modern industrial methods had created a lack of pride in workmanship, and so easy to think of workmanship simply in terms of the man at the bench and the machine. After all, in industry nowadays it was a fact that the men at the benches and the machines only represented about 30% of the people in industry, so it was not only necessary to worry about pride in workmanship in the case of the 30%, but more so in the case of the 70%.

It would be interesting to know how one applied the expression described by Sir Gordon Russell, " My word, she's a beauty," to perhaps the completion of some standard costs, or to finalise some production control project, unless of course it happened that they had been accomplished by a Marilyn Monroe of industry, in which case it was presumed that the expression could be used!

A few hours after he had read Sir Gordon Russell's excellent lecture, Mr. Dyson read a paper about William Brown, 1791-1864, and in it appeared the following: " The bad consequences of no interest in the job soon have the effect of making things considerably difficult and a falling off gradually takes place in the quality of the yarn spun. The frames begin to go ill. The quantity gets further reduced, waste increases, wages and expenses go up, the best hands begin to leave, accidents take place, fire breaks out, pilfering is practised, machinery is broken down. . . ." so that William Brown in 1791 was faced with a similar problem with regard to the question of pride in workmanship !

Personally, he believed that there were far more people who had pride in workmanship than ever before. When he looked round his establishment at the number of designers, draughtsmen and production engineers, he felt sure that there were many more getting a sense of pride from their job than was the case many years ago when the craftsman hacked out material with a chisel. What had been done was to transfer that creative instinct from a comparatively few craftsmen to a large number of designers, draughtsmen, engineers, tool and machine makers.

To-day's challenge was, of course, for management to create the desire for achievement. In that connection Sir Gordon had made some excellent points in his lecture. He pointed out that in the nineteenth century the description of employees was that of " hands " and it must be agreed that the term " hands " was obsolete in modern industry because people were now required to use their brains first and their hands second. That prompted him to suggest that it was time that industry dispensed with the term " charge hand ". Surely it would be much better to substitute the more enlightened term " section leader " or " team leader ".

The desire for achievement should be inculcated right from the hour an employee joined the company. He recalled in 1922 the appreciation he experienced in the United States, when the first thing that happened to him was to be shown round the plant. To-day, in his own organisation when new people joined the Company, one of the first things that happened was that they were taken for a tour round the offices and the factory.

Another worthwhile method of stimulating interest was to display prototypes of new products. If that were done at the prototype stage, some excellent ideas came from the men on the benches or the machines. Often in his own Company, when a job was put into production for the first time, a large model was made in section indicating what the working parts did, so that the man on the bench and the machine could see what was actually happening and what part he was playing.

On the question of the customers coming into contact with those making the job, he agreed with Sir Gordon Russell that it was an excellent idea, and it could be done by throwing open factories to visitors who could range from local school children to technical college and university students, but more important still, employees' relatives. He knew of no better way of getting pride in workmanship than allowing the relatives of employees to come round the factory and to see them working on a job.

Satisfaction in achievement was not always built up solely on pride in the job. For example, the large army of office workers could have little pride in the monotonous filling in and checking

of forms day after day, month after month. But they could derive satisfaction from the knowledge that they were salaried staff. They dined in the staff dining-room; they enjoyed industrial conditions of a higher order which allowed them to be paid a salary each week; they did not have to use a clock card, and in that respect they commanded the respect of the community. Pride in the progress of the Company could create satisfaction in achievement.

One of the most monotonous activities in the world could be to act on the stage. It was a soul-destroying job to speak the same words in the same sequence, to smile at the same time and to kick heels at the same time day after day, week after week, month after month and, sometimes, year after year. There was, however, a good deal of satisfaction in achievement to be derived simply from the appreciation of the audience. In other words, people derived satisfaction from the knowledge that other people knew that they had done a good job, and that was one of the things which it was necessary to capitalise in industry.

While modern industry was often right up-to-date in mechanical equipment, it seriously lagged behind in the human relations of which Sir Gordon Russell had spoken. How could one subscribe to a higher education by advocating an extension of the school-leaving age and by providing opportunities to go on to a higher education, yet expect to bring people into a factory to drill thousands of ⅛″ holes, to the accompaniment of "music while you work" designed to mitigate the monotony? Surely this was not the answer. The correct procedure was to do away with the drilling of thousands of ⅛″ holes, and to build up teams of people who had the satisfaction of making the completed part. That had been done in his own organisation over the past ten or twelve years, with a considerable increase in pride in the job and productivity. Those concerned in industry had been guilty of taking away the interest in doing a good job by copying the early American methods, made necessary by language difficulties, of having inspectors to spy out for and to throw out sub-standard workmanship, instead of realising that quality cannot be "inspected" into a job. Quality had to be put into the job by the man at the bench and the machine. It was necessary to ask the question why it was that the man at the bench and the machine regarded the shop steward and the trade union official as his leaders rather than the man who employed and paid him. Mr. Dyson suggested that this might well be the challenge of to-day.

On the question of design, there was no doubt that an appreciation of good design was desirable and that could well be cultivated in childhood, by ensuring that the toys which were given to a child were of good design. As Sir Gordon Russell pointed out, that could be followed up progressively in the case of equipment used at schools, colleges and so on, because it was at that impressionable age that the influence of good design could be most beneficial. In industry this could be done by the industrial leader who shows interest in the Horticultural Society, the Photographic and the Handicraft Sections in his own organisation.

Finally, he was grateful to Sir Gordon Russell for correcting the impression that it was Henry Ford who first made the statement about articles "painted any colour they pleased so long as it was black." As Sir Gordon pointed out, that statement was first made by Mr. F. W. Webb, in relation to locomotives.

The Chairman said there were approximately 50 million people in this country of which there were approximately 24 million who could be regarded as being gainfully employed. There were eight million of those employed in factories. He gave these approximate figures because the changing pattern of employment constituted one of the national problems. There was a slang reference to "big head." In other words, there was a big head and a small body; it was found that among those 16 million people serving the others there were about six million clerks. This broad reference was important, because it was necessary to think of the community as a whole, and not just one section of it.

Mr. Pittaway said he had hoped that some reference might be made to incentive payment systems. In his view, they had done more to kill pride in workmanship than anything else. He had been associated with a small product of high quality, and he could not quote one, but literally thousands of experiences of good craftsmen who had been penalised by their love for their art. A case which came to mind concerned a man who spent three weeks on a piece of quartz to get the job to a state of perfection. It was not a job which was done regularly, but the man liked to do that work, and he dropped about £2 a week in his wages through not being employed on producing the cheaper class of job. That was a problem which was common throughout the country.

A plea was made for craftsmanship and skill, but there was no offer or attempt to pay for it. The man who produced the cheap article by the thousand was better off financially than the man who was depended upon to produce a quality job.

Again, coming to the question of the clerical worker, how could a man be expected to have an interest in craftsmanship when he was earning £10 a week and paying out wages to an inferior of twice that amount?

Sir Gordon Russell, in reply, said he did not know whether he could answer that one! He did agree that it was a common problem. It seemed that under present-day conditions the craftsman was changing his actual function in so many ways in industry. He became much more the builder of machines, tool-maker, and so on, and when it was necessary to do some job by hand, ways had to be found of doing it. The question was how one could obtain the same interest in the job with a sub-division of work. He merely suggested in the lecture that one of the ways of doing that was by trying to get the man to see the whole of the job. The erection of the model of the machine so that the man could see what part he was playing, and showing the man round the factory could be used to illustrate that what appeared to be of little interest in the narrow sense was of some interest in the wider context.

The Chairman said that some years ago it was seen that skilled tool-makers, pattern-makers, and so on were leaving their skilled crafts and going on to machines and making more money; but it should be appreciated that there is a national agreement covering that very point. The tool-maker did, in fact, receive as a basic minimum the average earnings of the skilled production worker. Therefore in the well run and well organised establishment the toolmaker did, in fact, get as much as or more than the skilled production worker, and he was not forced to go at any higher speed than his craft demanded.

The craftsman was moving further and further back in the scheme of things, but he was still there and in greater numbers. He did not accept the statement that the clerk was necessarily any more valuable than the man in the shop. The great problem was that as a nation there were only eight million out of 24 million people actually producing in the shops and the position resembled a football match with twenty-two people playing and fifty thousand jeering or cheering them. There should be a greater incentive to all people who were making and creating.

Mr. J. Loxham (*Managing Director, Sigma Instrument Co.*) said that the Paper was of considerable value because it emphasised the importance of craftsmanship, which was something to which the nation must pay great attention. With the new machines the Indians and the Chinese could produce goods as well as semi- and unskilled people here, and they would win in the end from the point of view of labour costs.

When the question of craftsmanship was raised on television or in films and the like, one usually saw a man working with a potter's wheel or some antiquated contraption which was, perhaps, worth £20. In the eyes of some the craftsman was the man who could make a good article with a paltry piece of equipment. On the other hand, in the case of a machine worth perhaps £20,000 the man who was supposed to be operating it was unskilled or semi-skilled. That was wrong. What was needed, in his view, was the very best possible equipment, and it was necessary to put the very best possible people on to operate it.

If one were to speak factually about pride in workmanship it was necessary to devise some means whereby it was possible to measure the quality of workmanship. He was interested in measurement, and it was of importance to recall that Lord Kelvin about eighty years ago said: "To know what you are talking about you must be able to measure it and to be able to express the result in numbers." It was important to be able to express the result in numbers. He continued: "When you cannot measure and when you cannot express the result in numbers, your knowledge is of a very meagre and unsatisfactory kind." That must surely be right. If the desire were to build up craftsmanship, it must be understood that the very reliable

and, if completely understood, very beautiful unalterable laws of nature which operated in the craftsman's workshop, operated to exactly the same extent in the scientist's laboratory. By measuring that which was happening in the workshop it was possible to discover what was going on, and thereby do the particular job much better.

He had said before at meetings of the Institution and would say again that production engineering would become a science when the technique of measurement was adopted. It was when one measured something and observed the changes which occurred and obtained an intimate knowledge of those beautiful reliable laws of nature which controlled the process concerned, that one operated in a scientific manner. In his judgment progress would be made and pride in workmanship would be developed when modern equipment was used together with skilled craftsmen, and production engineering was made a scientific process.

In that respect he desired to comment on the steps which were being taken by the Government to increase technical education. While those steps were very welcome and, in many respects, very good, one thing was lacking. Those young men might go to the grammar school, and then at the age of eighteen, if they pass the examinations, they would go to colleges. They would finally be handed over to industry at the age of twenty-one and would theoretically be trained to run the factory. But who were running the factories of Britain at the present time so far as engineering production was concerned? They were not the highly intelligent people who went to grammar schools. They were people who had had practical training in their youth. That was of great importance, and in his view there should be opportunity for people to go into the factories, and since industry was paying the bill, the people whom industry had selected should be sent to technical colleges for further training.

On the question of monotonous work, in due time the thing called "automation" would no doubt be of help. He visited a factory in Scotland recently, and while there he saw some girls sitting in a row at a bench doing repetitive work and passing the product on to the next one. The manager asked whether it was possible to make a machine which would do that which the seven girls were doing. Of course it was. If the operation were of a routine straightforward character a machine could be made to do it, and the need of the future would be to have highly skilled people with a knowledge of scientific laws as applied to engineering production, taking a great pride in workmanship, standing back taking measurements and watching in some cases the automats producing goods of high quality at low cost.

Sir Gordon Russell, in reply, said that it was very important to be able to define but difficult to set down qualities in workmanship. During the War, when working on utility furniture he had been struck with the differences in the final article which came out of the various firms, about a thousand of which were working to a standard set of drawings and a standard specification. There were some firms which produced an article of furniture which ought never to be bought at all, and there were other firms which produced the same article but of a very fine standard. Pride in workmanship was evident in many, but absent in others. The fact was, of course, that it was not possible to make a man honest by a specification.

He was very sorry to say it in such an august place as the Royal Institution, but in his view Lord Kelvin was talking nonsense! There were so many things which were not measurable—so many intangible things. Everyone had a fairly good idea of what constituted good workmanship, but it was very difficult to define. One could not weigh nor measure the quality of English prose, but it is clearly recognisable to those prepared to spend long hours studying it. Shakespeare was unintelligible and boring to those who read nothing but comics.

Mr. Marsh said that, as had been pointed out already, pride in workmanship was not always capable of being inculcated into people in present times owing to the fact that they did not see the whole product; but he suggested that there was still room for pride in the product, and was it not a matter for those in supervisory positions to inculcate that pride? If a man were producing something that was very good, perhaps it was not sufficient to leave it to him to realise that it was good, but to have someone else point out that fact to him. Everyone enjoyed a pat on the back, and in his view it was one of the major factors which could encourage the pride in workmanship which was so important.

In the cases where it was not necessary to encourage pride in the product, there were other points about which it was worth thinking. One was the sense of purpose—a man being told why he was doing a certain job. He was more likely to respond to it if he were told.

An earlier speaker referred to the pay clerks paying out large sums to the workmen. The making up of wage packets was a monotonous job, but after a time the clerk probably forgot all about the amounts of money he was putting into the packets. Therefore it was important to seek some other satisfaction such as the feeling that he was doing a job that was useful.

Another possible pride which might be encouraged was pride in the plant over which one had control. Very often if new plant were installed, the man put in charge of it experienced a great sense of pride in that he had been entrusted with some new and expensive plant. That was a possible substitute for the old pride in producing an article.

Sir Gordon Russell, in reply, said he knew of many plants in which those in charge could take a great deal of pride, but the product which came out of those plants was something of which they might well be ashamed.

The Chairman referred to the question of the sense of purpose and said that he also used the expression "the feeling of belonging." The wages clerk, for instance, was paying wages and was putting into the pool something which would make the wheels of his community go round. That purpose could be inculcated in the managerial approach. He also supported the view expressed with regard to plant minding; for example, electricity going out from a power station could not be seen. One would have thought that it must be most monotonous to have no visible end product, but not on your life! The purpose of plant minding (plant made by skilled craftsmen) at a modern power station and power plant was an example of the pride that could be found in the men who looked after it. Therefore, the point made by Mr. Marsh concerning pride in the job being undertaken was most important.

Mr. Pirie, speaking, he said, in defence of Lord Kelvin, pointed out that the remark to which reference had been made was uttered during a lecture given by Lord Kelvin when he was Professor of Natural Philosophy at Glasgow and dealing with abstract physics. The remark, taken out of context, gave a wrong impression. On reading the full paper it was obvious that it fell into line, and from what one had learnt of Lord Kelvin, he was the last person who would attempt to apply that to any of the arts.

Mr. E. C. Gordon England said that although Sir Gordon Russell was no doubt aware of it, there was such a thing in industry today known as industrial discontent. It was widespread and growing very rapidly, but one might have thought from some of the remarks which had been made in the discussion that industry was completely free from any such disease. That disease was not accidental. It was necessary to realise that at the bottom of it all lay the dominant human motive—the creative motive. Unless that motive was recognised and served, it was obvious that a great amount of further damage might be done by way of increasing industrial discontent. If those who were privileged to hear the lecture took very seriously to heart its main message, a great deal could be done to rectify that situation. He, for one, was most deeply grateful to Sir Gordon Russell for the lecture.

He was horrified by the misquotation of Lord Kelvin. Industry and the Institution suffered greatly from such misquotations or quotations out of context. He could not help feeling that the idea of "measuring" the magnificent voice of some great artist was something that had defeated most people. At the same time, he wondered how one would "measure" Shakespeare. Industry must accept the fact that the things which ultimately mattered could not be measured. He felt sure that if there were any scientists present they would agree that the things which ultimately mattered were beyond their capacity at the present time to measure at all, and for that good reason these things were excluded from scientific research. It might

be that in years to come there would be a new concept of measurement, and there might then be some possibility. The contribution made that evening by Sir Gordon Russell was to pinpoint the need for preserving at all times the value of the creative motive in man.

Mr. Dyson made some really entrancing suggestions, one of which was the concept that people in industry should be divided into recognised groups. Mention had been made of the pay clerk and the Chairman had shown how the present industrial situation was tending to resemble a football match. When that did occur, Mr. England was prepared to prophesy that industrial discontent would reach crisis point and there would be a collapse of industry as we knew it. It was important to realise that it was necessary at all times to subserve the creative motive, and was it not possible that industry might have wages clerks in shops operating some machines for part of their working hours, because if discontent were to be spread among all wages clerks, he suggested that the football match, to which the Chairman had referred, would come to an end due to the fact that the players would be driven off by the angry crowd!

Sir Gordon Russell, in reply, agreed with the statement that there were a great number of things which could not be measured. That was a constant problem, for instance, in selecting designs. There was no absolute way of saying that they could be selected by some preconceived standard. It was well known that very often one generation would be completely out of touch with a great artist's work. He might be so far ahead of his generation that nobody understood him. Of course, if he were not sincere the misunderstood man might be a charlatan, but he might be a great artist, and it was only possible to assess his value finally in a later generation.

The Chairman said that about fifteen years ago one wages clerk made about 175 calculations a week. At the present time he made about 1,750 calculations a week, and the Chairman prophesied that within five years an electrician would do 27,500 calculations a week. Therefore, in that kaleidoscope of movement one could only hope that people would move towards being creative, and would respond to incentives to work, particularly young people. The subject matter of the lecture was important in that respect, because the future of the country depended on the young people now living in it, boys and girls between 15 and 20 years of age. What could be more wonderful than to create in other people the desire to create? One of the blind spots in industry and in the country was the vast number of young people from 15 to 18 years of age who were not receiving any tuition of the objective type. In Germany there were approximately 67% of boys and girls between 15 and 18 years of age who were being given objective training. The figure in Great Britain for the same age group was 23%.

It was necessary for everyone, and the Institution in particular, to set to and remedy that situation. Let more be put aside in an attempt to mould youth to take care of the future of this country.

Mr. L. Landon Goodman (*British Electrical Development Association*) said that a problem was created not only by misquotations, but also by the misuse of words. He was a little worried about what was meant by "creative." The average young man had a desire for adventure, which should be encouraged, but was adventure creative? The headlines in one of the daily newspapers that very day were "Preacher Runs Off With Baby Sitter"! They were in 2" type. It was necessary not to forget the world as it was today and what people wanted.

With regard to the question of pride in workmanship and its effect in industry, there was a report in the *Sunday Times* a few weeks earlier on restrictive practice in the shipbuilding industry, and it did not seem to be a very happy industry; but that was the industry which Sir Gordon Russell used as an example, when the workman referred to a ship as "She's a beauty," of pride in results. This might, of course, be an exceptional case.

Mr. Landon Goodman suggested that what was needed was a knowledge of philosophy, a knowledge of ethics and logic which would lead to a far greater understanding of men as men. There was a need for study and research in these other branches of science—the normative sciences and non-positive sciences. The positive had gone too far ahead of the normative sciences. For example, man in industry today was not fully employed. The man who was an expert beekeeper or an expert local town councillor was sometimes employed in industry pushing a truck around. Man was a remarkable object with many facets which no computor could embody. All management was not trained to use man, and because man was not humanly used he was discontented.

The part to be played by technical colleges had been emphasised. Many he had been into were excellent, yet in others there was not even a towel in the toilet and, walking round, 60 watt bulbs were seen hanging on flex. Again, technical colleges in many parts of the country were situated in squalid surroundings. Dirt was everywhere. There seemed to be no appreciation of the effect of such bad examples on the students.

Many of the points discussed that night were all part of a tremendous canvas, and the meeting could not hope to cover the whole of the industrial picture. He suggested that the answer would be given by continually studying man and finding out what his needs really were.

Mr. Waller referred to the question of measurement and said that even Leonardo da Vinci used a form of measurement in proportion, and that might be the point—measuring the proportion of something and not necessarily the definite dimensions. First, he used the golden circle, and many of the prominent artists of today used the golden circles to set out the proportions of their work. He wondered, therefore, whether measurement had not a place in the aesthetic sense of engineering as well as that which went on a canvas.

Sir Gordon Russell, in reply, said that it might be one thing to talk about the golden rule of proportion in relation to Italian art for, say, the proportion of window to wall in Florentine stone palaces, but when dealing with steel and glass the rule of proportion was different, because things could be done with steel and glass which could not be done with masonry.

The Chairman also referred to the question of measurement and proportion, and took as an example doorways. It would be found that in the days of the crinoline, doorways were measured to allow for the crinoline.

Again, he was in Malta last year and whilst there he visited a palace which had a beautiful spiral staircase. The history of that staircase was unusual and interesting, because in the early days the Knights did not walk up the stairs, but rode up a spiral road specially constructed up which their horses used to walk to the floors above. The spiral roadway was subsequently converted to a staircase, but the proportions of its design were measured by the horse and rider.

No doubt at the present time it would be a different design, but it so happened that this staircase was nicely proportioned.

In summing up, the **Chairman** said that in his view the chief point which had been emphasised in the lecture and discussion was the importance of individual people having a feeling of pride in themselves and in their work—that was absolutely fundamental. What was a nation? What was an industry? What was a factory? What was a meeting? It was a collection of people. That nation, industry, factory or meeting could not be any better than the people in it. He stressed this because there were too many sections of the population who kept talking about "they" and criticizing "them" as if there were only other influences on their lives and not their own. If care were not exercised the basic principles of individual contribution would be forgotten.

Referring to the question of joint consultation, there was a great deal which could be learnt from the Americans on that matter. It was sometimes amusing to the British to see the way the players went into a "huddle" during an American football match, but we would do well to emulate the American "huddles." In Britain there was too great an inclination for some people to say "That is my job and that is your job." It was essential to have early joint consultations not only between management and workpeople, but also horizontally between management and management, trade union and trade union, the chemist and the doctor, the metallurgist and the designer, the production engineer and the personnel manager, and most important, Government and Industry. If only it were possible to get out of the habit of saying "This is my job," and to get

into the habit of saying "This is *our* job," that feeling of pride of purpose and belonging, which was so necessary in industry today, would be inculcated.

As to greater pride in workmanship in the past, he rather disputed that. He had served his apprenticeship in marine steam and recalled as an example the tedious hours of trimming the huge blades of marine propellers with a hammer and chisel, and praying that the job would soon end! He knew of no pride in humdrum repetition, and as for those nine poor wretches referred to in the lecture who lugged a lump of lead through the bore, how his heart bled for them! Various humdrum tasks were still left, and how one persuaded the housewife to have pride in doing the "washing-up," he did not know. She appealed to the engineer to give her something which would do it for her mechanically.

In his view one should be proud of the house, proud of the street and proud of the city in which one was born, and the only way in which to show that pride was to put something *into* that house, that street or that city and not sit and wait for something to *come out* of it.

If all of us made the maximum contribution towards the well-being of our country, we should survive. If all we did was to *take out* all we could get, then we should fail.

Sir Gordon Russell said that one thing which had been learnt in Britain since the War was that one could not plan by telling people what they could not do. Something more positive was needed. As the Chairman had said, people were required who were prepared to put something into the pot instead of waiting for something to come out of the other end. It did not seem that there was any job in which people could not take pride if they did it as well as they could.

Mr. G. Ronald Pryor (*Chairman of Council*) said he desired, on behalf of all those present and the many members of the Institution who had not been able to attend but who would eventually read the lecture in the Journal, to thank Sir Gordon Russell for his Paper. The production engineer, possibly because his job more than that of most engineers was concerned with human beings, had been told that he must acquire much more of a liberal education than was thought normal in technical and scientific education today. We were being told that we must somehow or other get more of the humanities into the Institution's examination syllabus, and the lecturer had gone someway in curing the alleged defects of that sort for which members were most grateful.

Rightly, in view of the audience, the lecturer had stressed the engineering side of his theme, and Mr. Pryor was particularly interested in the part of the lecture in which Sir Gordon Russell emphasised the importance of, and drew attention to the great effect of, the sort of things about which he had been speaking on the general morale of people in a factory. On some other occasion one would like to hear him develop the other side of his subject which had, quite rightly, only been touched on lightly in the lecture, namely, how one assessed what was a good design, what was a bad design and, more important still, how did one differentiate between taste and fashion? What had been considered the worst possible taste in one period had often been the best possible taste in an earlier or later period. It was ridiculous to suggest that the ancient Greeks laid down for good and all the principles of design, and in his view it was equally ridiculous to suggest that the sort of things that some of the famous moderns inflicted upon people at the present time were good merely because they were new.

It was with great pleasure that he proposed a sincere vote of thanks to Sir Gordon Russell for having delivered a most stimulating lecture.

The vote of thanks was carried by acclamation.

The **Chairman** *expressed thanks on behalf of the Institution to the Royal Institution for having kindly offered the facilities of the Lecture Theatre.*

PRODUCTION EXHIBITION :-

Group Visits from Technical Training Establishments

The organisers of the Production Exhibition have drawn the attention of technical training establishments in the United Kingdom and Northern Ireland to the educational value of the Exhibition and the special facilities offered for visits by staff and student groups.

Any establishments not yet aware of facilities for group visits are required to write for particulars to: Andry Montgomery, Ltd., 32 Millbank, London, S.W.1, or telephone TATe Gallery 8134.

Firms operating apprentice or graduate training units are also invited to apply for concession tickets. Similar concession rates are open for organised parties of factory workers.

The Exhibition demonstrates productivity in British industry, its importance in ensuring the country's economic development, and the progress of modern trends of research, and is in no sense a "Trade Show". It affords an unique opportunity of obtaining an overall view of the progress of science, research and techniques in the evolution of British industry in a multitude of fields. As such, it offers considerable educational value and scope to staff and students from technical and industrial training establishments.

AMERICAN METHODS OF TRAINING IN INDUSTRIAL ENGINEERING & MANAGEMENT IN UNIVERSITIES AND INDUSTRIAL PLANTS

A Report by T. B. WORTH, M.I.Mech.E., A.M.I.E.E., M.I.Prod.E., F.R.S.A., Principal Senior Lecturer in Production Engineering and Assistant Head of Department, Department of Mechanical and Production Engineering, Birmingham College of Technology.

1. Introduction

1. 1. *Statement of Project*

The project on which this report is based was undertaken by invitation of the Ministry of Education, London, under the following terms of reference :-

> "To observe and gain experience of American methods of training in Industrial Engineering and Management both in Universities and Industrial Plants."

The project occupied six months of full time study, observation and practice. It involved contact and participation with 13 Universities and Institutes of Technology, and 19 industrial plants. These establishments were chosen to afford opportunities of appreciating industrial engineering and management principles and practices in organisations of different traditions and characteristics. This proved a wise approach in view of the diversity of method in both educational and industrial fields.

In addition to the above, the work and educational activities of a number of professional societies and trade associations was studied.

(List of Establishments consulted are given in Sections 1. 5 : 1. 6 : and 1. 7.)

IMPORTANT NOTE

The Productivity Report—"Industrial Engineering"—submitted by a Team which made a shorter visit to the U.S.A. in 1953, was not available prior to study in this project, but has become available since.

*A study of the above report (A.A.C.P.), containing as it does some pertinent references and sections to Education in the field, **shows that it is framed in such a way as vitally to affect this individual report.** This is reflected in Section 1.3 ; "**Object and Scope of the Report**" of this report.*

1. 2. *Method of Approach*

The project was planned as follows :-

1. 2. 1. A general survey of courses in industrial engineering and management in educational establishments.

1. 2. 2. A parallel survey of training and practice in the function in industrial plants.

1. 2. 3. A subsequent deeper penetration into course structure, content and teaching method in selected establishments.

1. 2. 4. Further industrial experience of a deeper character than that involved in the survey stage of the project.

This approach proved valuable as quite early in the project it became clear that ***there was a wide diversity of practices in both academic and industrial fields of Industrial Engineering.***

1. 3. *Object and Scope of the Report*

1. 3. 1. The scope of this report is confined to aspects of the subject not covered in detail, if at all, elsewhere.

It is framed to amplify education and training aspects, to clarify generalities and to provide guidance

in the development of courses in industrial engineering and management in academic and industrial areas in Great Britain. It is thus hoped to provide material of a fairly detailed nature to aid in the implementation of the recommendations of the A.A.C.P. Report, and particularly with reference to Chapter 19, "Education of the Industrial Engineer", and the Supplementary Report "Industrial Engineering Education in the U.S." with special reference to Sections XXXI - XL inclusive.

It is relevant to quote the recommendations of the A.A.C.P. Report, which embodies the considered opinion of a number of people chosen for their experience and qualifications in specific related fields.

Quote: 397. "Industrial Engineering Studies in universities and technical colleges, whether as single subjects or as courses should be expanded".

In view of the real difficulty which exists both in Great Britain and America over the question of terminology and definition, the following statement should be taken as applying throughout the report.

1. 3. 2. *Industrial Engineering and Management, for the purpose of this report, and, in fact, in practice, refers to a single area of education and training in which subjects from both the technological fields and the management areas are grouped to form a balanced course of study or programme of training.*

(The A.A.C.P. Report supports this view — see paragraph XXI, page 90 — quote :- "Industrial Engineering Courses are concerned essentially with methods of carrying out manufacture or service. They extend into management and related subjects because the two functions are inseparable".)

All subsequent references will, therefore, use the term INDUSTRIAL ENGINEERING implying combinations of technological and management studies.

1. 3. 3. *Industrial Engineering is considered as a Staff Function* providing a service to 'line' management in two major directions and taking responsibility for :-*

(a) *the evaluation and specification of the physical requirements for the manufacture of a product or the provision of a service*

and

(b) *the development and application of 'tool' subjects, mathematically based or otherwise, used by management in the direction, measurement and control of all processes and methods inherent in* (a).

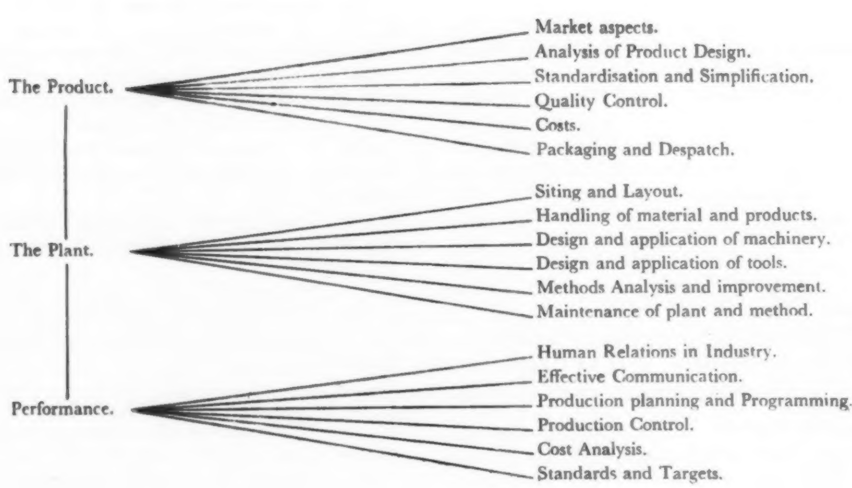
* *This does not preclude in any way consideration of the field of Industrial Engineering as a major area of training for potential executives.*

It is so considered generally in American industry and such consideration was found to be based on the opinion that the particular grouping of technological and administrative subjects found in Industrial Engineering makes it an ideal area of training for management, since during such training continual association with and contribution to management decisions will be normal practice.

Analysis of the practice of a number of American firms strongly confirms the above.

To complete the definition so that this report is specific and not weak through generalisation, the following chart shows the activities with which an industrial engineer may be concerned.

INDUSTRIAL ENGINEERING is concerned with the manufacture of a product or the provision of a service in three main areas thus ;-



Difference in emphasis provides the specialisation evident in both educational and industrial areas, and reflected later in reviewing some aspects of industrial engineering as a profession.

It is important to record that there exists a strong opinion that specialisation in parts of industrial engineering (e.g., Materials Handling Engineer or Methods Engineer), should be built on a sound general training and education framed in such a way as to establish the very real links between technology and administration.

Opinion was also expressed that the advance of technology today was so rapid and so revolutionary that it would be folly to consider technology and management as separate entities. The manager of the future must more and more have the ability to evaluate a new process or a new development of an existing process in terms of the industrial engineering aspect, and that means a sound knowledge of the technology. In the General Electric Company, which comprises 70 plants, over 80% of the senior executives are technically trained men.

It is thought essential to state as early as possible in this report that *the project revealed no vital area of study in the U.S.A. which is not being covered, both educationally and industrially, in Great Britain, although the degree of cover may vary.*

It did, however, reveal important differences in philosophy and conception, resulting in different combinations of subjects and difference in emphasis.

There were also differences in the ways and stages at which students were introduced to the subjects, and some diversity of opinion exists as to pre-requisites.

There is, however, a strong and growing body of opinion that studies in industrial engineering should be based on a basic engineering education, and that courses should include some study of technology of production.

An outstanding difference is that in U.S.A. students are introduced to the tool subjects of management relatively early in the course, the claim being that neither technology nor management can be studied in isolation where manufacturing activities are concerned. Any consideration as to ways and means by which studies in industrial engineering might be expanded in Great Britain must take into account the important facts that the educational systems of America and Great Britain have fundamental differences and have developed from different circumstances.

These facts alone preclude wholesale transfer of courses from one system to the other, even if that were desirable.

This report, therefore, presents a reasonably comprehensive and factual account of industrial engineering education and training functions in America, and presents suggestions concerning the ways in which a strong development in Great Britain might be fostered through modification and additions to existing courses.

1. 4. Educational Establishments in U.S.A. Contributing to this Project

By direct contact and participation :

1. 4. 1. Syracuse University, Syracuse, New York.
1. 4. 2. University of Illinois, Champaign, Illinois.
1. 4. 3. Northwestern University, Evanton, Chicago, Illinois.
1. 4. 4. University of Cincinnati, Cincinnati, Ohio.
1. 4. 5. Ohio State University, Columbus, Ohio.
1. 4. 6. Carnegie Institute of Technology, Pittsburgh, Pennsylvania.
1. 4. 7. Case Institute of Technology, Cleveland, Ohio.
1. 4. 8. Harvard University, Cambridge, Massachusetts.
1. 4. 9. Massachusetts Institute of Technology, Cambridge, Massachusetts.
1. 4. 10. Northeastern University, Boston, Massachusetts.
1. 4. 11. Cornell University, Ithaca, New York.
1. 4. 12. University of Wisconsin, Madison, Wisconsin.
1. 4. 13. Georgia Institute of Technology, Atlanta, Georgia.

In addition to the above, other establishments gave freely of their views and practices through representatives at the 62nd Annual Meeting of the American Society for Engineering Education (A.S.E.E.).

1. 5. Industrial Concerns in U.S.A. Contributing in this Project

1. 5. 1. General Electric Co., Electronics Park, Syracuse, New York.
1. 5. 2. International Haweston Corporation, Chicago, Illinois.
1. 5. 3. Cincinnati Milling Machines, Cincinnati, Ohio.
1. 5. 4. Method Engineering Council, Pittsburgh, Pennsylvania.
1. 5. 5. United States Steel Corporation, Pittsburgh.
1. 5. 6. Lincoln Electric Co., Cleveland, Ohio.
1. 5. 7. Wheeler Associates Incorporated, Cleveland, Ohio.
1. 5. 8. United Shoe Machinery Corporation, Boston, Massachusetts.
1. 5. 9. New Process Gear Corporation, Syracuse, New York.
1. 5. 10. Carrier Corporation, Syracuse, New York.
1. 5. 11. Lamson Corporation, Syracuse, New York.
1. 5. 12. Rollway Bearings Corporation, Syracuse, New York.
1. 5. 13. Prosperity Company Incorporated, Syracuse, New York.
1. 5. 14. Oberdorfer Foundries Inc., Syracuse, New York.

1. 5. 15. La Pointe Machine Tool Co., Hudson, Massachusetts.
1. 5. 16. Eastman Kodak Co., Kodak Park, Rochester, New York.
1. 5. 17. Eastman Kodak Co., Camera Works, Rochester, New York.
1. 5. 18. Delco Works, (General Motors), Rochester, New York.
1. 5. 19. Will and Baumer, Syracuse, New York.

1. 6. **Professional Societies and Trade Associations Consulted**
1. 6. 1. American Society for Engineering Education, (62nd Annual Meeting).
1. 6. 2. American Institute of Industrial Engineers.
1. 6. 3. American Society of Tool Engineers.
1. 6. 4. American Society of Mechanical Engineers.
1. 6. 5. Manufacturers' Association of Syracuse.

2. General Notes on Industrial Engineering in the U.S.A.

2. 1. *Professional Aspects*
It is interesting to report that the development of industrial engineering professionally in the U.S.A. has been attended by problems of tradition similar to those attendant on the progress of production engineering in Great Britain.

The terms 'industrial engineer' and 'industrial engineering' have, however, become widely accepted, and where this is not so, as in some Universities, it is because of those problems of tradition and development. The rapid and impressive expansion in the employment of industrial engineers in American industry is shown by the following comparative figures :-

BRANCH	1940*	1950**	INCREASE %
Civil	105,500	124,600	18
Electrical	55,700	93,400	68
Mechanical	85,500	98,600	15
Industrial	9,800	46,700	376
Metal and Mining	9,800	25,900	164
Chemical	11,600	31,100	168

*U.S. Census Bureau P.44 No. 1. Feb. 1944.

**Engineering Manpower Commission, March, 1948.

Note :—A survey entitled "The Industrial Engineering Profession" (Georgia Institute of Technology) is included in the library copy of this report.

2. 2. *Educational Aspects*
Although technical education in America developed in most cases without control from a central authority, indirect control in the form of 'accreditation' of courses, traditional practice and imitation has resulted in some similarity of approach. Sufficient freedom exists, however, to allow individuality and initiative to develop a broad pattern of courses.

This is noticeable in the field of industrial engineering which, compared with the traditional areas—civil—electrical—mechanical, is comparatively recent as a *separate area of study*. The administrative aspects of industrial engineering and what is now time and motion study were introduced with existing courses on an experimental basis about 1900.

No general agreement exists as to the 'best' form of course or the best grouping of subjects and it is significant to note that in tables of Education Statistics, the term "Industrial Engineering" includes "Administrative Engineering" and "Management Engineering".

(The adoption of the term "Industrial Engineering" *as standard nomenclature* for courses has not taken place for several reasons. One of these, a pertinent one, appears to be because of the desire to retain existing and traditional titles, of accepted respectability.)

Thus a course may be quite definitely a course in industrial engineering and be labelled as such in University literature, yet it may carry the award of B.M.E. (Bachelor of Mechanical Engineering), or B.Sc. (Bachelor of Science).

The width of the field and some indication of the formative thought which surrounds the development of courses in industrial engineering in the U.S.A. is given in the following tables which are derived from an article in the Journal of the American Institute of Industrial Engineers. It is significant to report that the survey indicated in the tables was undertaken by a graduate industrial engineer as a thesis for a higher degree.

If guidance is to be given in the development of courses in industrial engineering, a very clear understanding must exist as to the subjects of study which are involved. Tables I and II are included to show how very wide this field is and it is clear that specific areas of optimum relevance to Industrial Engineering must be stated.

(Tables I and II are reproduced from :- "Concept and Practices in Industrial Engineering". Ralph E. Balyeat, Purdue University. A.I.I.E. Journal, Vol. V, No. 3, May, 1954.)

3. Industrial Engineering Education

3. 1. *Some Comparative Statistics*
Both in America and Great Britain it has become the general practice to assess the development (quantitatively) of a new field of study in terms of the more traditional fields of civil, mechanical and electrical engineering.

To give an appreciation of relative volumes of study in industrial engineering in U.S.A. the figures at the foot of the facing page are extracted from Circular 387 of the Office of Education, Washington, D.C.

TABLE I

SUBJECTS COMMONLY FOUND IN INDUSTRIAL ENGINEERING CURRICULA

Order of Importance as Reported by Educators		Order of Importance as Reported by Companies Employing Industrial Engineers	
Rank	*Subject*	*Rank*	*Subject*
1.	Motion and Time Study.	1.	Mathematics.
2.	Accounting.	2.	Plant Layout.
3.	Mathematics.	3.	Operation Analysis.
4.	Operation Analysis.	4.	Plant Operation.
5.	Industrial Organisation and Management.	5.	Motion and Time Study.
6.	Labour Relations, Personnel.	6.	Production Engineering.
7.	Mechanics.	7.	Factory Planning.
8.	Physics.	8.	Wages, Job Evaluation.
9.	Plant Layout.	9.	Production Planning.
10.	Factory Planning.	10.	Mechanics.
11.	Production Planning.	11.	Production Control.
12.	Mechanical Drawing.	12.	Mechanical Drawing.
13.	Technical Writing.	13.	Labour Relations, Personnel.
14.	Strength of Materials.	14.	Industrial Organisation and Management.
15.	Engineering Materials.	15.	Human Engineering.
16.	Production Control.	16.	Industrial Reports.
17.	Engineering Economy.	17.	Quality Control.
18.	Statistics.	18.	Surveys and Reports.
19.	Technical English.	19.	Engineering Economy.
20.	Economics.	20.	Industrial Economics.
21.	Production Engineering.	21.	Physics.
22.	Electrical Engineering.	22.	Statistics.
23.	Plant Operation.	23.	Safety Engineering.
24.	Wages, Job Evaluation.	24.	Technical Writing.
25.	Quality Control.	25.	Technical English.
26.	Industrial Economics.	26.	Accounting.
27.	Tool Engineering.	27.	Mechanisms.
28.	Business Law.	28.	Machine Design.
29.	Thermodynamics.	29.	Economics.
30.	Machine Design.	30.	Tool Engineering.
31.	Human Engineering.	31.	Engineering Materials.
32.	Safety Engineering.	32.	Electrical Engineering.
33.	Mechanisms.	33.	Strength of Materials.
34.	Chemistry.	34.	Chemistry.
35.	Metallurgy.	35.	Finance.
36.	Surveys and Reports.	36.	Metallurgy.
37.	Fluid Mechanics.	37.	Fluid Mechanics.
38.	Industrial Reports.	38.	Business Law.
39.	Finance.	39.	Thermodynamics.
40.	Government and Political Science.	40.	Government and Political Science.
41.	Surveying.	41.	Surveying.

TOTAL ENROLMENTS

Engineering Curricula	*No. of Schools*	*Full-time*	*Part-time and Special Day*	*Evening*	*Total*	*No. of 1st Degrees* 1952-53
Electrical	170	30,775	363	3,254	34,397	4,905
Civil	168	21,109	202	1,532	22,843	4,400
Mechanical	168	31,898	393	3,193	35,484	5,917
Chemical	122	13,152	48	693	13,893	2,276
Industrial	78	6,208	89	744	7,041	1,525

TABLE II

CONCEPTS OF INDUSTRIAL ENGINEERING FUNCTIONS

The survey questionnaire presented a list of functions frequently associated with industrial engineering, and suggested that they could be thought of as consisting of two phases of activity.

Design

The study, planning and development of the methods, procedures or systems required to control the performance of the function.

Administration

The actual performance or control of the function utilising the designed methods, procedures or systems.

The respondents were asked to indicate whether or not they regarded these functions as industrial engineering functions. The percentage listed represent affirmative answers and are based on total response indicated in column headings.

Function	*Companies*		*Consultants*		*Educators*	
	Design %	*Admin.* %	*Design* %	*Admin.* %	*Design* %	*Admin.* %
Production Plan and Scheduling	63.3	36.6	71.4	28.6	86.2	48.3
Production Control	52.3	36.2	85.7	28.6	79.3	51.7
Material Control	45.1	30.6	7.14	14.3	69.0	41.4
Inventory Control	37.9	24.2	57.1	14.3	55.2	34.5
Quality Control	40.9	31.9	57.1		72.4	55.2
Office and Plant Layout ...	82.5	50.2	85.7	57.1	96.6	51.7
Design of Equip. of Factory ...	64.2	33.6	71.4	14.3	58.6	20.7
Tool Engr., Jigs and Fixtures ...	52.7	31.1	85.7	14.3	79.3	48.3
Maintenance—Mach. and Equip.	34.0	21.7	28.6	14.3	27.6	24.1
Maintenance—Build. and Facil.	30.2	21.3	28.6	14.3	17.2	17.2
Safety Programmes	34.0	29.4	28.6	14.3	58.6	44.8
Waste Elimination and Salvage	59.1	40.4	85.7	14.3	72.4	51.7
Office Management and Proc.	34.5	18.7	85.7	14.3	55.2	27.6
Process Engineering	66.8	43.4	100.0	57.1	62.1	58.6
Methods Analysis and Stand ...	87.2	66.8	100.0	71.4	96.6	69.0
Personnel Policies and Proc. ...	23.4	19.6	14.3	14.3	31.0	10.3
Training Programmes — Prod. Worker	34.4	27.7	57.1	28.6	44.8	31.0
Labour Rel. — Griev. Settle ...	21.3	20.4	14.3	14.3	27.6	17.2
Job Evaluation	68.1	58.3	71.4	71.4	86.2	58.6
Merit Rating	38.3	33.2	42.9	42.9	58.6	31.0
Time Study	83.4	75.3	100.0	85.7	89.7	69.0
Rate Setting	75.7	68.1	85.7	100.0	86.2	62.1
Wage Incentive Schemes ...	73.2	65.9	85.7	85.7	82.8	55.2
Cost Est. — Production	65.5	54.9	85.7	85.7	79.3	31.0
Cost Records and Control ...	33.2	26.8	28.6	14.3	65.5	34.5
Special Projects	51.1	39.1	71.4	14.3	44.8	24.1

A most significant development in U.S.A. has been the expansion of industrial engineering studies at the *graduate level,* and some idea of the subjects forming the basis of these studies will be given in Section 5 of this report.

The following figures (Circular 387—Office of Education), give a comparative assessment of the volume of graduate studies in industrial engineering.

Engineering Curricula	*Enrolment Ratios as % Undergraduates*	*Master's Degrees 1952-53*	*Post-Grad. Deg. Not Doctorates*	*Dr's. Deg.*	*Total Higher Degrees*
Electrical	19.5	866	14	132	1,012
Civil	9.6	560	13	32	605
Mechanical	10.4	608	19	78	705
Chemical	17.5	433	—	147	580
Industrial	22.2	215	7	3	225

It has been estimated that 60% to 70% of students who follow a formal course in what might be termed "pure engineering", have moved to executive positions involving industrial engineering when they are ten to fifteen years out of college.

This can, of course, be interpreted as showing the value of the traditional courses—as it does indeed. But discussion with industrialists indicated that a more rapid personal development might have resulted from the inclusion of some industrial engineering studies in the engineering course.

Similar estimates have been made in Great Britain and the question appears very pertinent at a time when it is most essential to serve the individual and industry by an efficient development of available student man-power.

3. 2. *Educational Survey*

It was previously stated that course content varies in the U.S.A. considerably. Later in the report, this diversity will be reduced in the light of trends in America and of possible developments in Great Britain.

It is not practicable to devise a chart or other visual aid which gives a ready appreciation of the diversity of course structure.

It is, however, generally accepted that there are three main methods of approach in America.

3. 2. 1. A technique approach where the emphasis is on the study of theory and application of management "tool subjects"—e.g., Time and Motion Study.

3. 2. 2. An engineering analysis approach in which each situation or problem is analysed and wherever possible, measurement is used for assessment of the problem.

3. 2. 3. A management approach where the emphasis is on management studies, largely taught *via* the case system.

Of these, the engineering analysis approach is rapidly gaining favour as a method which most readily performs the service required in industrial engineering studies and, most important, an approach which lends itself to the classical appreciation of education by developing the ability to think logically. It also measures up to the demands of an expanding technology.

NOTE :—The library copy of this report contains an extract from "The Accredited Industrial Engineering Curricula" Georgia Institute of Technology.

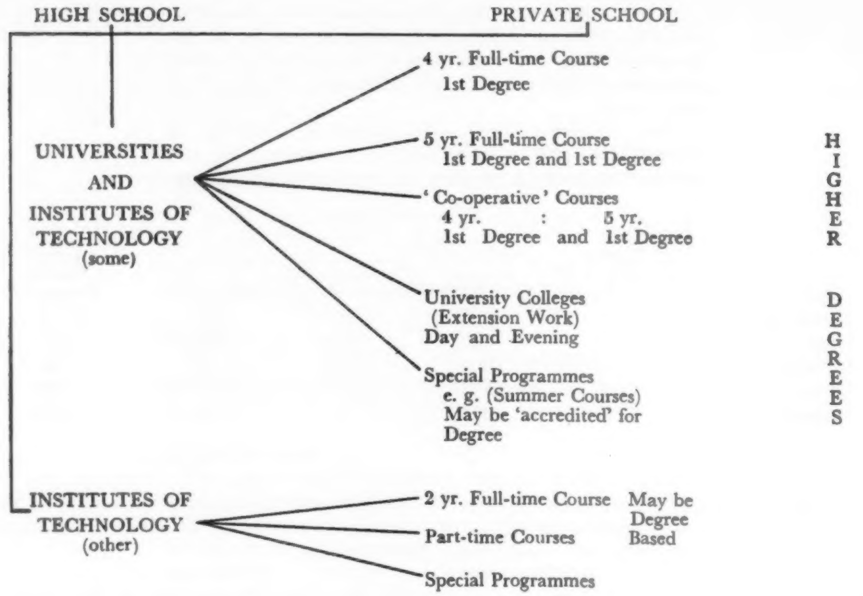
3. 3. *Notes on American Education*

Study of the analyses given in previous sections of this report will have indicated the wide diversity of practices and course structure, and it would be confusing to attempt to illustrate every combination. On the other hand, it is thought advisable to show typical patterns so that a well defined base exists for the consideration of ways and means of developing studies in industrial engineering in Great Britain. The following examples have therefore been chosen to show different methods of approach and represent areas which were studied in some detail by the reporter during the project.

Previous mention has been made of the differences between the system of education in U.S.A. and that in Great Britain, and this is most important when considering basic structures. These differences exist in both the administrative sphere and educational sphere, resulting in establishments which may be privately endowed, state aided or a combination of these methods. (At Cornell University, and others, there exists on the campus, side by side and welded into the University structure, colleges which are privately endowed and those which are state aided).

There is no system in America which exactly parallels the National Certificate Scheme in Great Britain and it is relevant to comment that this scheme with its industrially based students and unique combination of practical training and academic study in parallel, excites much interest and appreciation in the United States.

The following chart shows in broad conception, the areas of American education relevant to this report :-



3.4. *Pre-requisites to a study of Industrial Engineering*

Much thought has been given during recent years on the important question of the most suitable preparation for a study of industrial engineering.

Attendance at the 62nd Annual Meeting of the American Society for Engineering Education provided a valuable opportunity to sound current opinion on this matter from representatives of a large number of establishments.

There was general agreement that the desirable attitude of mind to be brought to a study of industrial engineering was that involving the 'engineering method and philosophy'.

Thus the majority of courses in industrial engineering leading to a first degree are based on a previous preparation in engineering with a course content mainly in the mechanical engineering field—but *not exclusively*. In such courses, it is the practice in the four-year courses to make the first two years of this nature. Alternatively, the course may "involve such studies" as a pattern or thread running throughout.

Courses with a 'Management' approach particularly those at the graduate level (i.e., post first degree), are often based on a first degree in either engineering or science.

The following examples will clarify the detail involved in these approaches.

3.5. *Typical Courses*

The following outlines have been chosen to illustrate methods of approach and to help in the definition of industrial engineering as a field of study.

They do not include an example from every University or Institute of Technology visited during the project. This neither indicates assessment nor preferment as every institution has been of great value—and all were freely given—in forming a realistic and balanced appreciation of industrial engineering in the U.S.A.

In some instances, graduate studies have been shown immediately subsequent to the related undergraduate courses. In others, graduate courses have been shown separately because of some particular aspect which it is deemed necessary to illustrate.

3.5.1. 4-*Year Full-time Course*

Syracuse University—New York State Department of Industrial Engineering

The philosophy of approach at Syracuse University is well illustrated in "Definition and Scope of Industrial Engineering". The form of the course is not final, as at the time of the project much consideration was being given to the way in which the course could be strengthened by incorporating some study of manufacturing activities in the process area.

These deliberations are typical of the thought being given to re-design of courses in a number of Universities and Institutes of Technology.

Development of courses in Great Britain is discussed later, but it is relevant here to comment that such deliberation gives much point to the A.A.C.P. report recommendation that industrial engineering courses should be developed with and from courses in production engineering.

"Definition and Scope of Industrial Engineering"

Industrial engineering is the engineering of manufacture. It is the application of engineering methods, practices, and knowledge in the manufacturing division of industry. Its activities include :-

1. The selection of manufacturing processes and assembly methods.
2. The design of the physical facilities of the plant, including :-
   (a) arrangement of machines and equipment;
   (b) the material handling equipment;
   (c) the materials and product storage facilities.
3. The selection of tools and equipment.
4. The design of control systems for :-
   (a) production;
   (b) inventory;
   (c) quality;
   (d) manufacturing costs;
   (e) maintenance.
5. Cost reduction.
6. Development of wage payment systems and job evaluation.
7. Evaluation and performances.

Other engineering activities usually found in industry concern product, sales, application, research, plant and special processes.

Manufacturing activities which are closely related to industrial engineering activities are the following :-

1. Tool design and tool making.
2. Plant engineering, including :-
   (a) maintenance of machines, equipment and buildings;
   (b) building construction and alteration;
   (c) power plant operation;
   (d) plant protection.
3. Purchasing.
4. Cost accounting.
5. Personnel administration, including :-
   (a) selection of employees;
   (b) training of employees;
   (c) merit rating;
   (d) safety.

Industrial engineering is a staff function and as such is advisory in nature. There are two very important reasons for this. First, this avoids complicating the line authority of the operating personnel. Second, and equally important, is the difference in attitude and approach between management and industrial engineering. The industrial engineer must have an investigative type of mind and be especially capable of analysis, design and evaluation. Management is involved with the execution of the plans based on information from industrial engineering. Co-ordination and leadership ability are the most important traits of management. A person educated as an industrial engineer and who has had considerable industrial experience practising his specialty is excellently equipped for management *if he has the interest and leadership talents.* His knowledge of overall plant operation is of great value in a management position.

DEPARTMENT OF INDUSTRIAL ENGINEERING.
SYRACUSE UNIVERSITY

The first year of work in the *College of Engineering* is uniform for all students.

Studies in the first and second years are not specifically in the industrial engineering field. Thus the I.E. Course is really a two-year course following general scientific and engineering subjects.

3rd Year

1st Term

Manufacturing Processes.
Processes Laboratory.
Industrial Engineering.
Mechanics of Materials.
Materials Testing Laboratory.
Principle of Electrical Engineering.
Electronics (General Studies).

2nd Term

Production Methods.
Methods Laboratory.
Plant visits and reports.
Job Evaluation and Wage Incentives.
Engineering Statistics.
Electrical Engineering.
Electronics (General).

4th Year

1st Term

Thermodynamics.
Mechanical Engineering.
Industrial Engineering Seminar.
Motion and Time Study.
Estimating and Costing.
Production Planning and Control.
Electronics (Technical).

2nd Term

Fluid Mechanics.
Engineering Economic Analysis.
Quality Control.
Plant Design and Layout.
Electronics (Technical).
Electronics (General).

AWARD :- BACHELOR OF INDUSTRIAL ENGINEERING

GRADUATE STUDIES

The Graduate School permits studies in some of the above subjects to be continued to a higher standard and offers in addition :-

Safety Engineering.
Materials Handling.
Industrial Engineering History. Organisation and Administration.
Plant Engineering and Maintenance.
Economics of Machine selection and replacement.

Coupled with Thesis requirement.

AWARD :- MASTER OF INDUSTRIAL ENGINEERING

3. 5. 2. *A Full-time 5-year Course (Non-state University)*

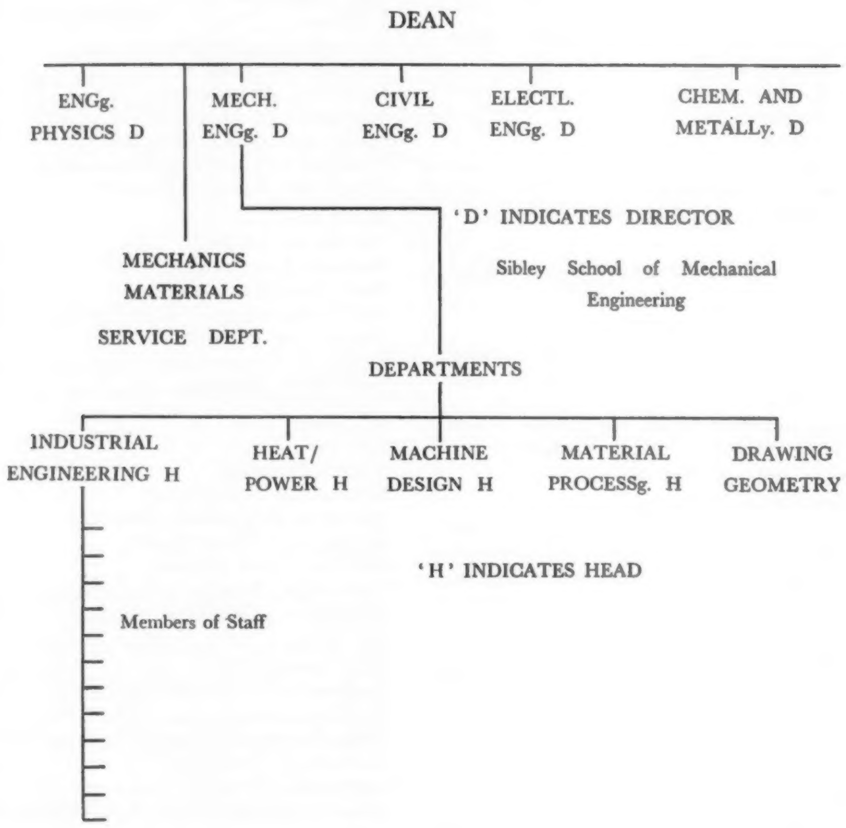
Cornell University—College of Engineering.
Sibley School of Mechanical Engineering.
Department of Industrial Engineering.

The writer spent four weeks at Cornell University as a visiting Fellow at the invitation of the President of the University, and it is thought that the following brief notes on general University Structure will give background to other references dealing with general patterns.

CORNELL UNIVERSITY. ITHACA. NEW YORK

COLLEGE OF ENGINEERING

ORGANISATION (PARTIAL)

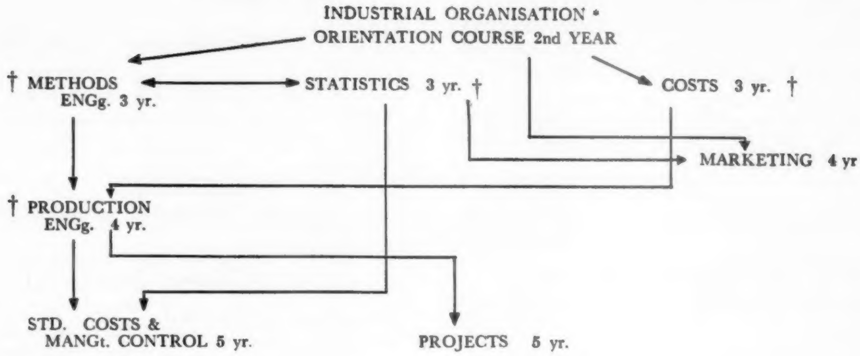


INDUSTRIAL ENGINEERING AT CORNELL UNIVERSITY

Programme note, 1954

'The training of engineers for the field of production engineering or industrial engineering has been an integral part of the Sibley school of Mechanical Engineering for the past fifty years. The increasing scientific developments underlying the operation of works and plants in many industries have put additional emphasis on the need for a sound background in such areas as materials, design, statistical procedures, materials processing, gauging and inspection, methods engineering, cost accounting and production engineering including product analysis, plant layout, engineering economy and production control'.

The courses are based on the following general pattern which becomes effective during the second year of the course. The first year is largely concerned with general science and engineering science and these continue in part during the second year.



*Compulsory for all Engineers

†CORE SUBJECTS. *Taken by all engineering students*

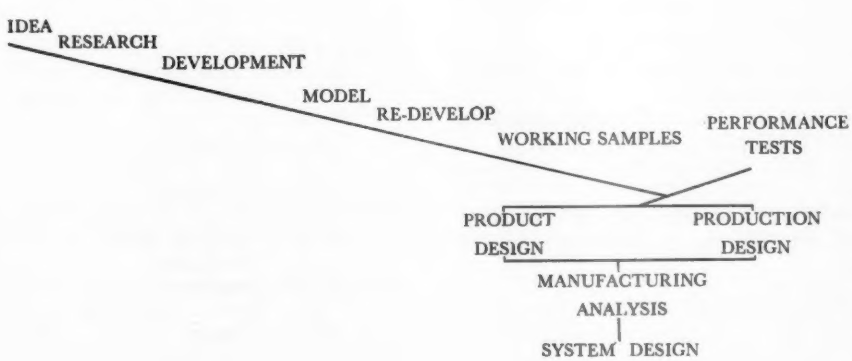
Electives

STATISTICAL QUALITY CONTROL.
ADVANCED STATISTICS.
PRODUCTION CONTROL.
ADVANCED METHODS ENGINEERING.
ADVANCED PRODUCTION ENGINEERING.
PERSONNEL MANAGEMENT.
MARKET RESEARCH.
AWARD :- B.M.E. (Bachelor in Mechanical Engineering).

Production Engineering

In view of the confusion which exists with respect to interpretation of titles, the following defines this term in relation to the work at Cornell University.

'Production Engineering encompasses Methods Engineering and involves the design of the production system. This requires evaluation of alternatives —regarding the system on a whole. The process can be appreciated by reference to Production Design and Development'.



3. 5. 3. *A Full-time 5-year Course (State University) The Ohio University, Columbus*

At this University, the University year is divided into four quarters, each almost eleven weeks in length. The University comprises ten Colleges and a Graduate School.

Industrial engineering in the College of Engineering is framed on the idea that it comprises these areas of study or division of work.

Works Area.
Management.
Work Methods.
Planning and Control.
Industrial Relations.
Production Engineering.
Plant Layout.

GENERAL PATTERN OF INDUSTRIAL ENGINEERING COURSE. (Ohio State University)

First Year

This is common to all five-year curricula in engineering, and establishes a basis of fundamental science with an introduction to engineering.

Second Year

Mathematics (Calculus).
Physics (Mechanics. Heat. Light. Sound. Electricity. Magnetism).
Industrial Engineering. (Processes — machine. Foundry. Welding).
Principles of Economics.

Third Year

Mathematics—Statistical Methods in Engineering.
Mechanics—Statics and Dynamics or Mechanics of Fluids.
Accounting—Principles, Factory costs.
Engineering Drawing.
Industrial Engineering—Manufacturing Processes.
Mechanics—Strength of Materials.
Psychology—introductory; physiological psychology; advanced psychology.
Industrial Engineering—Engineering Management; Production Control Charts.
Economics—Labour problems.

Fourth Year

Industrial Engineering — Methods Analysis; Works' Measurement and Standards.
Electrical Engineering.
Industrial Electronics and Controls.
Business Organisation—Personnel Management.
Applied Thermodynamics.
Industrial Engineering—Engineering Economy.
Industrial Engineering—Tool Engineering.
Industrial Engineering—Advanced Production Control.
Industrial Engineering—Safety Engineering.
Industrial Engineering — Industrial Quality Control.
Political Science.
Social Administration.
Machine Design.
Economic Geography.
Business Organisation—Corporate Organisation and Control.

MAY BE TAKEN FOR GRADUATE CREDIT

SUMMER QUARTER is devoted to practical experience in an industrial organisation.

Fifth Year

Survey of Engineering.
Industrial Engineering—Plant Equipment and Design.
Industrial Engineering—Production Engineering.
Industrial Engineering—Advanced Studies.
Non-technical Electives } From other related areas,
Technical Electives } chosen to give a coherent sequence of studies.

MAY BE TAKEN FOR GRADUATE CREDIT

AWARD:- B.I.E. (Bachelor of Industrial Engineering).
and—M.Sc. (Master of Science).

Part concurrently or post bachelor's degree.

Analysis of the course shows that what may be subjects under the heading Industrial Engineering, represent 77/286 of the course or rather more than 25%.

3. 5. 4. **Institute of Technology Courses**

'A' Georgia Institute of Technology, Atlanta, Georgia — (see also section 2 of this report).

This Institute has one of the largest enrolments in industrial engineering in the U.S.A. The Director of the School of Industrial Engineering and the staff take a most active part in the affairs of the American Institute of Industrial Engineers, whose Journal is produced in Atlanta.

FOUR YEAR COURSE

First year is common to all engineering students and aims to establish a base of fundamental science.

Second Year

Engineering Drawing.
Principles of Economics.
Survey of Humanities.
Calculus.
Welding Lab.
Pattern and Foundry Lab.
Machine Lab.
Physics.

Third Year

Economic Principles and Problems.
Accounting and Cost Accounting.
Metallurgy.
Technical English.
Organisation of Production.
Production Control.
Evaluation of Engineering Data.
Motion and Time Study.
Applied Mechanics.
Thermodynamics.
Heat — Power Engineering.
Machine Design.
Electives.

Fourth Year

- Public Speaking.
- Fluid Mechanics.
- Applied Electricity.
- Heat — Power Lab.
- Industrial Psychology.
- Industrial Accident Control.
- Industrial Surveys and Reports.
- Cost and Production Estimating.
- Factory Planning.
- Materials Handling.
- Job Evaluation and Wage Incentives.
- Engineering Economy.
- Legal and Ethical phrases of engineering.
- Electives.

'B' INDUSTRIAL ENGINEERING OPTION IN MECHANICAL ENGINEERING, CASE INSTITUTE OF TECHNOLOGY — CLEVELAND, OHIO

SUBJECT GROUPS AND SUBJECTS	YEAR PERCENTAGES			
	1.	2.	3.	4.
BASIC SCIENCE Mathematics. Physics. Chemistry.	57	36		
HUMANITIES AND NON-ENGINEERING STUDIES Composition. Background of Democracy. History of Western Civilisation. Electives.	32	20	20	20
RELATED ENGINEERING STUDIES Engineering Drawing. Mechanics. Heat—Power. Machine Design. A.C.—D.C. Machinery. Metallurgy.	11	34	67	49
INDUSTRIAL ENGINEERING STUDIES Mechanical Processes. Production Engineering. Methods Engineering. Quality Control. Production Control. Plant Layout.		10	13	31
	100	100	100	100

The course content at this establishment may be shown in terms of broad groups of subjects as shown below :-

In the 2nd and 3rd years, the following are essential studies.

Mechanical Processing I and II
Production Engineering I and II } See later details

In the 4th year electives are offered from :-

- Methods Engineering.
- Industrial Plants.
- Fundamentals of Quality Control.
- Welding Processes.
- Production Control.

Typical syllabuses are given to establish an appreciation of the content of the Industrial Engineering subjects.

Immediately following this survey of undergraduate studies, graduate studies are cited to preserve continuity.

MECHANICAL ENGINEERING

Undergraduate Courses *Industrial Engineering Division*

M.E.1. *Mechanical Processing* 1. Fundamental theory and processes used in machining metals on basic machine tools. Types of equipment, tooling, coolants, machinability, sequence of operations and the relationship between metal processing and mechanical engineering.

M.E.2. *Mechanical Processing* 2. Theory and practice in casting ferrous and non-ferrous metals, design and construction of wood and metal patterns, moulds and cores, supol and crucible furnace operation, sand-control equipment and testing, operating costs and economical production methods.

M.E.8. *Practice Term in Mechanical Processing.* A continuation of M.E.1 and M.E.2. Practice demonstrations, discussions and inspection trips covering mechanical processing and production methods. Equivalent industrial experience may be substituted upon approval. Two weeks in summer.

M.E.9. *Inspection Trip.* An out-of-town-trip to visit engineering industries and manufacturing plants not found in the Cleveland district. Discussions are conducted daily and a formal report is required. One week at the end of the junior year.

M.E.45. *Production Engineering* 1. Technical factors involved in production processing, manufacturing equipment and facilities, material requirements, tooling and operation planning machine and plant utilisation, inspection procedures and control, maintenance and safety measures.

M.E.46. *Production Engineering* 2. Techniques of economic analysis applied to production problems. Cost considerations and budgetary control, economic alternatives, depreciation and replacement studies, material and manufacturing quantities and analysis of operating efficiency.

NOTE:- M.E.1; 2; 8; 9; 45; and 46 ARE COMPULSORY.

M.E.140. *Methods Engineering.* Methods of analysing manufacturing operations to find the most economical way to do each job. Process charts, operation charts, micro-motion study, principles of motion economy, job standards and time standards.

M.E.142. *Industrial Plants.* Factors in the co-ordinated design of an industrial plant including production methods, equipment and services, layout, material handling and control, selection of equipment, economic lot sizes and manufacturing costs, laboratory layout of manufacturing areas for specific production requirements.

M.E.143. *Fundamentals of Quality Control.* Application of statistical methods to control the quality of manufactured parts. Statistical principles for determining frequency distribution design of control charts and inspection plans. Technique of inspection and gauging, inspection devices and gauge-testing equipment.

M.E.144. *Welding Processes.* Fundamentals of welding, covering the common phases of gas, arc and resistance welding. Practice on arc and gas welding in the laboratory.

M.E.145. *Production Control.* Basic principles and factors in production control. Planning, routing, scheduling and dispatching in manufacturing programmes. Laboratory analysis and solution of typical cases from industry.

M.E.240. *Advanced Methods Engineering.* Establishing of job standards, rating studies, standard data and basic time values, production studies, formulation and charting. Motion study applications to process, operation, equipment and handling problems. Laboratory development of techniques and equipment for obtaining data and application of principles to production problems.

M.E.241. *Industrial Engineering Management.* Seminar. Factors underlying management decision. Plant organisation and operation. Inventory, budget, finance-control systems, purchasing and material control, production planning and personnel management. Visiting lecturers present current views and applications.

M.E.242. *Industrial Law.* Laws of incorporation, federal law and fair-trade regulations, patent law and copyrights. Case studies.

M.E.244. *Production Control and Planning.* Production-control requirements and methods. Product-design market analysis process engineering, material control, manufacturing, scheduling, dispatching and records.

M.E.245. *Job Evaluation and Wage Administration.* Methods of preparing job descriptions, making job analyses and appraising the value of specific jobs. Employee remuneration with particular emphasis on incentive systems.

M.E.246. *Labour Relations.* Techniques and strategy of joint labour-management relations including state and federal regulations, collective bargaining, labour contracts, grievance procedure, conciliation and arbitration.

CASE STUDIES IN INDUSTRIAL ENGINEERING AT CASE INSTITUTE OF TECHNOLOGY

Taken after Industrial Experience

These studies, taken after industrial experience are designed to provide a well rounded, thorough and critical study of established principles and new developments in the field.

Full-time students usually complete the course, which leads to the degree of Master of Science in Industrial Engineering, in one year.

An evening schedule is also provided and the qualification is gained after four years of part-time study.

In addition to the normal range of graduate studies, a most interesting range of related courses is offered.

GRADUATE STUDIES

Methods Engineering and Advanced Methods Engineering.
Plant Layout and Materials Handling.
Statistical Quality Control.
Welding Processes.
Production Control and Planning.
Applied Industrial Statistics.
Industrial Law.
Investigation in Industrial Engineering.

RELATED COURSES IN INDUSTRIAL ENGINEERING AND MANAGEMENT. GRADUATE LEVEL

Instrumentation and Automatic Control.
Machine Analysis.
Analytical Techniques.
Momography.
Mathematical Statistics.
Semomechanisms.
Illuminating Engineering.
Cost Accounting.
Corporation Finance.
Problems in Administration.
Scientific Method.
Industrial Production Management.
Job Evaluation and Wage Administration.
Labour Management Relations.
Human Problems in Industry.

3. 5. 5. **Further Graduate Studies**

To maintain course sequence, certain graduate courses have been outlined subsequent to the related undergraduate courses.

However, it is a common practice in the United States of America to qualify in a science or technology, and to add to such qualification a graduate study in the field of Industrial Management. Many Universities and Institutes of Technology operate Schools of Business Administration and there are some links in such schools with parallel courses in Industrial Administration. For instance, a School of Industrial Engineering may give a service course in Time and Motion Study for students in Business Administration. Similarly, a School of Business Administration may offer the subject of Production Management for graduate studies.

Two of the best known areas of Graduate Study have developed at Harvard and Massachusetts Institute of Technology, and examples of courses there are given to show the pattern of such development. The courses are definitely biased towards Industrial Management but the links with Industrial Engineering (which essentially embrace some Management aspects), is noticeable.

GRADUATE SCHOOL OF BUSINESS ADMINISTRATION—HARVARD UNIVERSITY CAMBRIDGE — MASSACHUSETTS

The courses in this school are aimed at 'Administration'—'the determination and execution of policies involving action'.

The two-year course leads to a Master's Degree in Business Administration and the first year of the course is divided into these areas of study:-

Administrative Practices.
Business Responsibility in the American Society.
Control.
Finance.
Marketing.
Production and Written Analysis of Cases.

The second year is devoted to more difficult problems in:-

Administration and Review of Accounts, Advanced Economic Theory and Analysis.
Advanced Production Problems.
Advertising.
Analysis of Markets.
The Business Administration and Government Policy.
Business Conditions.
Business History.
Business Policy.
Economic Aspects of Public Policy.
Factory Management.
Financial Accounting.
Financial Management.
Foreign Trade Management.
Human Relations.
Industrial Accounting.
Investment Management.
Legal Aspects of Business.
Management of Financial Institutions.
Management of New Enterprises.
Manufacturing.
Personnel Administration.
Problems in Collective Bargaining.
Retail Distribution.

Sales Management.
Taxation.
Transportation.

It is not proposed to repeat detailed analyses of these courses but to point out several aspects which may inpinge on teaching methods and approaches in the area of Industrial Engineering, which, as has been stated elsewhere in this report, is fundamentally linked with both Technology and Management.

Pre-requisites

1. A first degree is preferred but not essential.
2. The first degree may be in Liberal Arts or Science or Engineering. It was significant that the proportion of Graduates in Engineering who take the course has increased from 10% to 30% in about ten years.
3. Selection takes account of personal qualities as well as attainment and about 600 students are accepted from an application of 2,500.

Technical Content of Courses

Harvard approach to technical content is to give students sufficient appreciation of subjects to enable them to realise the areas of application and to know when to use the services of a specialist.

Shop Drawing. This subject is used as a means of communication and it is claimed that students readily acquire the facility of reading fairly complicated drawings.

Operation Sheets and Machine Tools. The equipment consists of a lathe, shaping machine, grinding machine, drill press, milling machine. All these are bench models, mounted on trolleys for classroom use. Machine tool illustrations with current prices are used to encourage economic appreciation.

Time and Motion Study. Interest is centred on the management aspects and the main areas covered are :-

(a) explanation of and practice in use of decimal timer and in setting of standards ;
(b) discussion of causes of difference ;
(c) discrimination between scientific areas and non-scientific areas.

Films are used extensively to develop powers of perception.

The following is quoted from the 'Official Register' to give an appreciation of the essential difference of approach to manufacturing aspects in business administration courses and that in engineering courses.

The problem of 'how much manufacturing technology' in industrial engineering courses is still a debatable one in the United States of America.

" Production is an operating subject that deals with methods and techniques of execution and supervision to a greater extent than with policy formulation. The problems are selected from the production field and include the more important procedures and techniques commonly employed in progressive manufacturing plants. These techniques are studied with reference to the development of an understanding of their contribution to the attainment of established manufacturing objectives.

" The subject is organised to make four well defined contributions to the first year programme :-

1. It provides an appreciation of the relationships of production to other operating problems of business and an awareness of the significance of production aspects of general administrative problems.
2. It gives familiarity with and a degree of facility in the use of procedures and techniques that have had their greatest development within the factory and that are rapidly gaining much wider significance as their more general administrative applicability is recognised.
3. It develops self-confidence and recognition of personal capacity and capability in technical and mechanical areas that many individuals have too commonly looked upon as outside their *forte.*
4. It emphasises the development of a variety of important mental characteristics, such as critical perception, imagination, analysis at the factual level and judgment.

" Production provides the technical foundation for second year advanced operating courses and for courses that are concerned with formulation of production policy. It is a laboratory type course, in which the student learns by doing." (From Prospectus.)

ADVANCED PRODUCTION PROBLEMS

" This course deals with the broad problems in production policy which confront the executive in charge of manufacturing operations. The solution of such problems frequently requires an understanding of the manufacturing process in which it operates. The course has, therefore, three objectives :

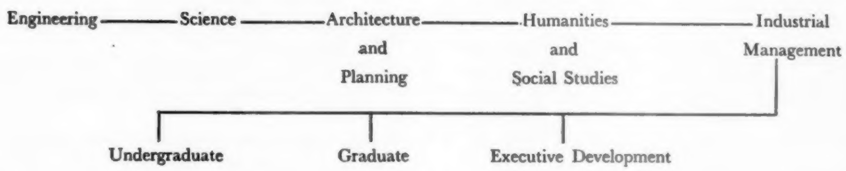
" The first objective is to develop the student's ability to analyse a manufacturing process and to determine quickly the things about it which are important for top management to know and understand. Attention is directed to the way in which the fundamental technology of a process influences management policy decisions, the organisation of industries, and the operating methods of particular companies. Plant inspection trips are made to provide practice in the use of first-hand observation as a means of learning about the management problems presented by particular production processes.

" The second objective is to develop the student's ability to analyse the structure of manufacturing industries and to evaluate the competitive, economic, and technological forces at work in them. Emphasis is placed upon the impact of changing industry conditions on management methods. The industries studied include furniture, textiles, plastics, radio-television, steel and petroleum..

" The third and most important objective of the course is to develop the student's capacity to formulate programmes and policies for industrial companies which are feasible in terms of the basic characteristics of the production processes and which are consistent with current trends and conditions in the industries in which the companies operate. The case problems are broad in scope, and considerable attention is given to the correlation of manufacturing programmes with the marketing, financial, research, and other policies of the companies."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—
CAMBRIDGE—MASSACHUSETTS.
SCHOOL OF INDUSTRIAL MANAGEMENT

M.I.T. General Organisation with special reference to Industrial Management



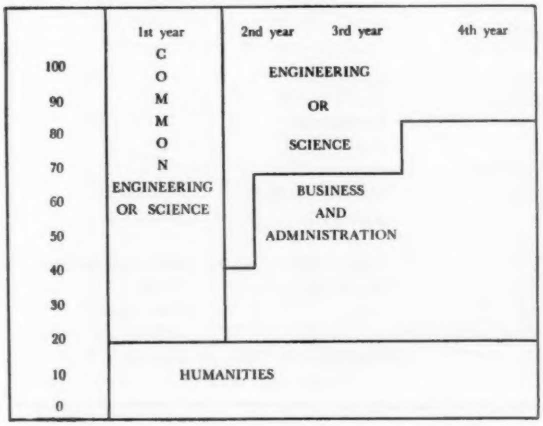
The School was established in 1951 and co-ordinated long standing activities at M.I.T. — undergraduate courses in " Business and Engineering Administration (1914) ". Graduate Course in Industrial Management (1925), and the Executive Development Programme (1931).

The School of Industrial Management effects a co-ordination of science and engineering knowledge with administrative skill and this is encouraged by :-

1. *A pre-requisite for Graduate Study in the School in undergraduate work in Science or Engineering.*
2. *Undergraduates* in the School spent more time in technical studies than in any other single area of study.
3. Scientists and Engineers of the M.I.T. Faculty regularly report new developments to all graduate students.

UNDERGRADUATE COURSE

COMPARATIVE COURSE CONTENT



Comparative Enrolment at M.I.T. 1952/53

	Undergraduates		*Graduates*
Electrical Engineering	450	63.4%	400
Mechanical Engineering	300	18.5%	150
Industrial Management	250	11.0%	100

" Two undergraduate courses are offered — one based on the physical sciences and the other on the chemical sciences. Both lead to the degree of Bachelor of Science. The technical components of these curricula are designed to lay a solid foundation for effective industrial management."

(*see left below*).

Minnowbrook, Blue Mountain Lake. A conference centre of Syracuse University.

It was stated that the students were interested in Engineering or Science as a means to an end but wished to cover broader aspects of technology and its implications. The undergraduate course aims to fit men for medium sized business.

An important aspect of the curriculum structure is that *the Engineering and Science studies for students in the School of Industrial Management are the same as for students who stay in Engineering or Science.*

'Management' represents 25% of the whole course and to allow this, subjects related to laboratory and design in the 'pure' technical course have been removed.

In discussion of these aspects, members of the Faculty stated that Alfred P. Sloan, who was the Founder of the Alfred P. Sloan Foundation Inc., which made the grants for the foundation of the School, realised the need for Executive training and believed that this could best be done in an engineering environment.

The Engineering and Scientific studies impose a discipline which has been found of great value for management problems and gives an engineering approach to problems in Buying and Selling, for instance.

The manufacturing area or 'value added' area was chosen as being the most general area.

These brief observations are very pertinent to considerations of Industrial Engineering, which embraces both Technology and Management.

GRADUATE WORK

The diagram below shows a typical graduate programme:

Other Second Year Subjects

- Problems in Industrial Economics.
- International Problems.
- Historic Studies in Innovation.
- Government Regulation of Industry.
- Problems in Accounting Control.
- Collective Bargaining and Union-Management Co-operation.
- Public Policy on Labour Relations.
- Organisation.
- New Product appraisal and Development.
- Manufacturing Policy Seminar.

The Executive Development Programme

This programme prepares men already holding responsible positions in industry, for dealing with the broader and longer-term problems likely to be encountered as they assume higher responsibility.

Entry Qualifications

(i) A minimum of five years industrial experience.
(ii) A demonstrated aptitude for growth in management.
(iii) (Preferably) a background in Science and Engineering.

TYPICAL GRADUATE PROGRAMME—M.I.T.

<table>
<tr><th rowspan="2">AREA</th><th colspan="2">FIRST YEAR</th><th colspan="2">SECOND YEAR</th></tr>
<tr><th>First Semester</th><th>Second Semester</th><th>First Semester</th><th>Second Semester</th></tr>
<tr><td>Economic and Social Environment.</td><td>Economic Analysis.</td><td>Business Economics.</td><td></td><td>Fundamental Legal Principles.</td></tr>
<tr><td></td><td>Economic and Business History.</td><td></td><td></td><td></td></tr>
<tr><td>Human Relations in Industry.</td><td>Interpersonal Relations.</td><td>Labour—Management Relations.</td><td colspan="2">Personnel Administration.</td></tr>
<tr><td>Operational Tools of Management.</td><td>Accounting and Cost Analysis.</td><td>Industrial Statistics.</td><td>Quantitive Analysis of Industrial Problems.</td><td></td></tr>
<tr><td>Management Problems.</td><td>Manufacturing.</td><td>Distribution. Finance.</td><td>Manufacturing Analysis.</td><td>Financial Admin.</td></tr>
<tr><td></td><td></td><td></td><td>Industrial Marketing.</td><td>Administrative Policy Seminar.</td></tr>
<tr><td></td><td></td><td></td><td>Thesis.</td><td>Thesis.</td></tr>
</table>

3. 5. 6. **Special Courses**

In the U.S.A. the practice of conducting special courses and Summer Programmes is widespread. Related to this is the establishment of 'Engineering (and other) Institutes' as a department of the University. Such organisations maintain a very close liaison with professional societies, and industry and related organisations.

For the purpose of this report, comment is confined to two examples in which the writer participated, one technological and one in the management field.

Technological

Massachusetts Institute of Technology — Summer Programme. Course three weeks full-time. Tuition fee — 160 dollars, say £60. *"Numerical Control of Machine Tools."*

This course centred on a Research Project undertaken by the Servo-mechanisms Laboratory of the Department of Electrical Engineering. The material of the Course was thus of the greatest value since the topic was right in the forefront of current thought and practice. It is not the purpose of this report to set out the theory of Numerical Control, but to illustrate the approach and thoroughness of the treatment, the following lecture headings are given. These are 'Chapter Headings' and represent the main topic of the series of lectures, which was very adequately supported by demonstration on the machine unit.

Each person on the Course contributed to a group project (in groups of two or three), and the results of the computation were fed to the machine and a component produced. Finally, each member was sent a full set of notes, excellently produced, in print, and a punched tape record with a machined component.

Numerical Control of Machine Tools

1. Introduction.
2. The M.I.T. Machine.
3. Numerical Control Systems.
4. Genro-mechanisms for Machine Tools.
5. Feed-back Instrumentation.
6. Digital Building Blocks.
7. Decoding Techniques.
8. Data Processing.
9. Data Storage.
10. Data Input Equipment.
11. Hardware for Numerical Control.
12. Programming for Numerical Control of Machine Tools.
13. Programming for the M.I.T. Numerically Controlled Milling Machine.
14. Data Processing by Machine.
15. Man—Machine Liaison.
16. Management Considerations Associated with Numerical Control.

In the U.S.A. the provision of Special Courses, aimed at bringing to the notice of industry the why and how of recent developments, is considered a most important educational activity. In this respect, the courses projected at M.I.T. for 1955 are listed to give an appreciation of the range. The courses are generally of two weeks' full-time duration and involve residence.

Course Topics

Industrial applications of Heat Transfer to Electronics.
Plastics in the Design of Building Products.
Biophysical and Biochemical Cytology.
Uses of Accounting in Managerial Control (3 weeks).
Weather Radar.
Creative Engineering and Product Design.
Parachute Technology.
Switching Circuits.
Ionising Radiations for Industrial Processing (1 week).
Separation by Diffusional Processes.
'Incident Process' in Management Development.
Fundamentals of Inventory Management.
Numerical Analysis.
Food Technology.
Wear Theory in Metal Cutting and Bearing Design.
Science Teachers Programme (6 weeks).
Numerical Weather Prediction.
Soil Engineering for Airfields and Highways.
Behaviour of Materials at Elevated Temperatures.
Colloid Science.
Real Estate Finance.
Aerodynamics of Unsteady Flow.
Technique of Infra-red Spectroscopy (1 week).
Noise in Electron Devices.
Strain Gauges: Fundamentals (1 week).
Low Temperature Engineering and Research.
* Noise Reduction.
City and Regional Planning.
Numerical Control of Machine Tools.

* It is relevant to comment that the Industrial Engineer in American industry is becoming increasingly aware of the need to reduce noise associated with manufacturing processes. An example of this was observed at Eastman Kodak, where a number of presses were acoustically screened.

4. Notes on the Teaching of Industrial Engineering

4. 1. *General*

During the project an attempt was made to assess methods of approach in the study and teaching of the various subjects at both undergraduate and graduate level. No fundamental differences from practices in Great Britain were apparent, except those arising from the differences in the educational system.

Certain distinct and apparently widely used practices were however noted, and these are given here.

4. 1. 1. *Use of Text Books*

Most of the schools and colleges worked closely to a list of standard text books. Teaching and schemes of work were based on these. Throughout the courses, reading assignments were given and test questions, often of a very searching nature, were asked to educe the student's understanding of the text. Such a

practice did not exclude the excellent documentation for courses which is mentioned later.

4. 1. 2. *Student participation*

A strong impression was formed that students were expected to work throughout with a considerable show of initiative in private reading and searching for knowledge of the particular subjects being studied. The lectures and laboratory periods were by no means the sum total of the system. (Full-time study obviously provides more opportunity for such practice than does part-time study, but the question as to how much a lecturer should do for students and how much students should be encouraged to do for themselves is felt to be an important one.)

4. 1. 3. *The Case System.* (*Management Areas*)

This was used in two main forms — as a complete and self-sufficient method of student development; and as an essential adjunct to a lecture system. Within the limits of the project, the latter system appeared to have distinct advantages.

During participation in a specific case, it was noted that from a class of 80 graduate students, about 25% participated — group discussion of the case had taken place previously.

At the School of Industrial Management at M.I.T. some departure from the formal case method was taking place, and a method of 'situations' was being developed in which discussion took place with industrialists who were actively seeking a solution to a common problem.

Allied with this, students were required to compile a book of excerpts from leading authorities and add their own notes for assessment.

4. 2. **Specific Areas of Study**

At the undergraduate level in full-time courses, such areas were used to give engineering background knowledge since the students were 'college based' and in the main had little background such as is gained by an engineering apprentice in Great Britain following a part-time scheme of education.

Consequently during the first two years of courses in engineering, periods in the workshops were a necessary part of the scheme.

At the graduate level, however, it was apparent that the process area was used wisely as a field for research.

As in Great Britain, the level of provision of equipment varied greatly but the following examples are thought worthy of special mention.

4. 2. 1. *Machine Laboratory—University of Illinois*

The lecture room is adjacent to the workshop and there is provision for the transfer of machines from the workshop to the lecture theatre by means of overhead mono-rail. A turntable in the lecture theatre enables comprehensive demonstrations to be given. (*see photographs below*).

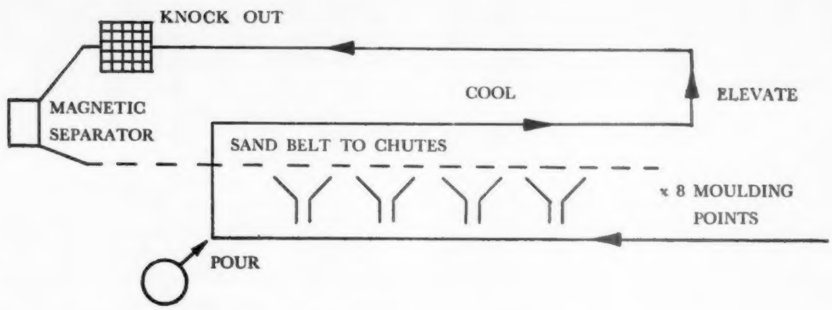
Foundry

Many of the establishments visited regarded the foundry process as a vital area of study since it was illustrative of a primary process serving many industries.

At the Ohio State University a very good foundry and associated laboratory had been developed.

The foundry was planned as fully mechanised and the area used for illustrating the principle of continuous production. The line diagram on the facing page illustrates the general arrangement.

Machine Laboratory — University of Illinois.



Work based on the production of units such as
A. POLISHING HEAD
B. DRILL PRESS

Work based on the production of units such as :-
A. POLISHING HEAD.
B. DRILL PRESS.

A sound appreciation of the approach to teaching in the Process Area may be obtained from a Paper prescribed at the 1954 Summer School for 'Machine Design and Manufacturing Process Teachers'. — Mechanical Engineering Division of the American Society for Engineering Education. This Paper—"Teaching of Manufacturing Processes" by Professor M. L. Begeman, University of Texas—contains a survey of practices in 35 Engineering Colleges. Generally this suggests the view that different approaches are essential in full-time courses and part-time courses.

4. 2. 2. *Statistics*

The study of Statistics and Statistical Method was found to attract high esteem in most of the establishments visited. In some, *all* engineering students were required to take a course in this subject and at the graduate level, full use was made of it as a primary tool subject.

For example, wherever possible, Work Study analyses were subjected to statistical tests for assessment of their validity.

Two methods of approach were used to reduce the 'arithmetical effort' in the working of examples from tabular information. The students were either given the salient values ready derived from the lists of figures, or they had access to some form of calculating machines.

The following are typical of the areas studied :-

Analysis of Variance.
Tests of Significance.
Graphical and Mathematical Correlation.
Statistical Tolerance Analysis.
Design of Experiments.
Sequential Analysis.
Process Operational Studies.

At Cornell University, Statistics has long been a requirement of all students in the School of Mechanical Engineering. The following notes arose from a discussion with Dr. Robert E. Bechofer, Associate Professor in the Department of Industrial Engineering. They are given to illustrate the findings resulting from a relatively lengthy experience in the teaching of Statistics in Industrial Engineering Courses.

SOME NOTES ON THE TEACHING AND EFFECT OF STATISTICS IN I.E. COURSES

It has been found that a knowledge of Statistics is beneficial to all M.E. Students and could well extend into other fields, the immediate need being to establish the subject in Chemical Engineering Courses and Electrical Engineering Courses.

The pattern of studies at Cornell is :-

Theoretical Statistics.
Advanced Statistics.
Quality Control.
Sampling Inspection.

It was considered that provided students had a good understanding of the application of the Calculus to problems involving areas under curves, moments of inertia and centre of gravity and similar fundamentals, elementary statistics could be taught to them with some effect.

Statistics should be introduced as soon as students had mastered the pre-requisite knowledge of Calculus, since it carried on the rigorous approach of formal mathematics.

The aim should be to produce men with a ready appreciation of a situation in which statistics could be of help—that is, recognition of a situation in which statistics could act as a *major* tool of solution, though it may not be the only tool required. The subject provides a bridge between theory of mathematics and practice and encourages scientific method. (It was realised that Quality Control—as a technique—could be taught without a deep knowledge of statistics).

Student surveys showed that they appreciate the value of statistics but wished for more problems solving. This implied practice and the labour of handling large amounts of data could be reduced in two ways :-

(a) By the provision of calculating machines.
(b) By presenting to the students the completed computations of basic elements such as 'sum/1 and sum/2'.

Statistics were considered to fit normally into the pattern of studies expected of students in I.E., and some assessment of its value as a discipline is indicated that the failure rate at the first attempt averaged about 10%.

It is the practice in the establishments visited during the project to hold Seminars—that is meetings related directly to, but not part of the *formal* teaching periods—at which staff or students present a Paper for discussion on some aspects of the studies.

Such a Paper relating to Statistics is, 'The Statistical Approach to Decision Making', by Dr. Robert C. Bechofer, Cornell University.

One way in which Statistics is approached and the importance attached to the subject in the U.S.A. is indicated by the following quotation from the above Paper.

"The problem posed by each question (i.e., in the Paper) is, 'What statistical rule should be followed in order to answer the question in such a way that all of the requirements of the question are satisfied?'

"The rule itself tells how many observations are to be taken, how the data are to be analysed and *what course of action is to be taken based on the results of the analysis*".

4. 2. 3. *Engineering Economy*

One of the most noticeable characteristics of U.S.A. courses in industrial engineering was the accent on 'cost' and the development of 'cost-consciousness' in students. When related to technology, this can be a very powerful tool subject and since 'engineering economy' is based primarily on application of interest formulae, it has a general application of great value. Moreover, it has been developed in industry to give engineers the ability to assess the relative economies of alternative technical projects.

The subject occurs in most courses in industrial engineering and special sessions were devoted to its discussion at the 62nd Annual Meeting of the American Society for Engineering Education.

Engineering economy deals mainly with the preparation of cost studies of engineering projects and their significance. The subject receives the support of industry. For instance, in the telephone industry, as in any other industry, the requirement for construction of plant for expansion, betterment or other reasons may offer a choice as to the action to be taken.

Where a choice can be made, it is the responsibility of the engineer to determine the plan which will meet the physical requirements in the most economical manner and to take this into consideration in recommending the course of action to be taken.

It is recognised, however, that costs are only one of the many factors to be explored before reaching a decision to go ahead with a project at a given time and in a given way.

(Reference 'Engineering Economy'—American Telephone and Telegraph Company).

The subject matter in 'Engineering Economy' relates mainly to the 'Mathematics of Money in Cost Studies' allied to the critical assessment of alternative engineering schemes, and includes such matters as, First Cost and Associated Cost of Money and Depreciation Equivalence ;

Assured Earning Power of a Reserve Fund ;

Fundamental techniques of Economic Selection Studies :

- (a) Annual Cost Comparisons.
- (b) Present Worth Comparisons.
  - (I) Present Worth of Expenditures.
  - (II) Present Worth of Annual Charges.

Economy Studies reflect the overall economic advantages of one plan of action compared with another, for the whole life of the plant involved.

4. 2. 4. *Plant Layout and Materials Handling*

This subject occurs either in two parts or as a combined subject as dealt with here.

The approach is in the nature of project work and although we have yet to find a mathematical basis for many of the problems involved, it was found to be of great importance to students of industrial engineering. In view of its importance care was taken to assess its value to the students and the following statement is made with confidence.

Plant layout and materials handling is a subject—one of the few subjects—which enables the student to correlate all his studies, in both the technological and management area, and to produce a tangible result which can be analysed and assessed against the requirements of the problem.

Thus, to give but a few of the areas which might be used in such a problem, there are location of industry, choice of site, factory organisation, production processes, factory services, transportation, mechanics of handling, time and motion study.

The subject also has importance in that it provides the student to display his ability in relating the 'tool subject' and whilst some of the subject may be taught formally, e.g., the Work Study aspects of Material Handling, much of it is developed through student activity.

The photographs on the facing page are reproduced by courtesy of the Georgia Institute of Technology, and illustrate the solution of students to typical problems.

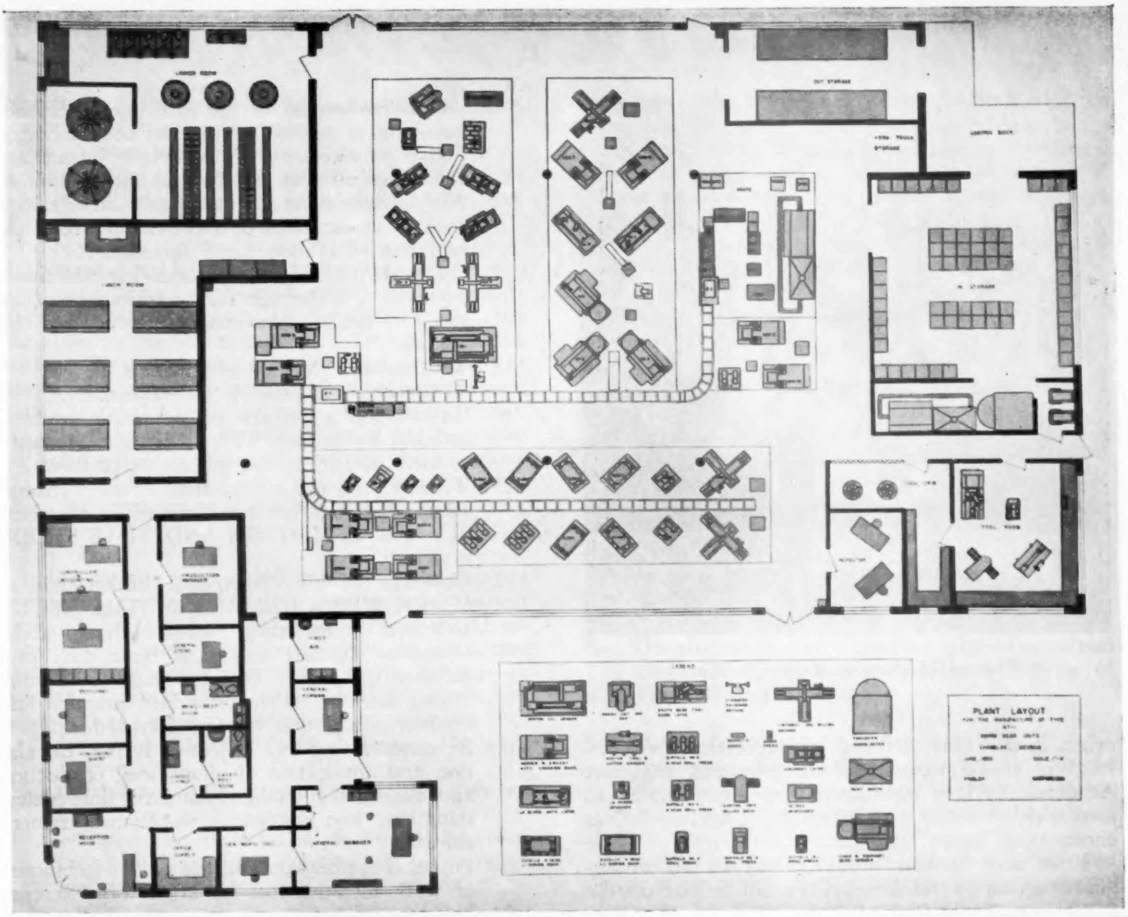
In the U.S.A. much thought has been given to the ways in which plant layout and plant re-layout—two associated aspects—might be facilitated, and during project work, students are made familiar with the techniques developed.

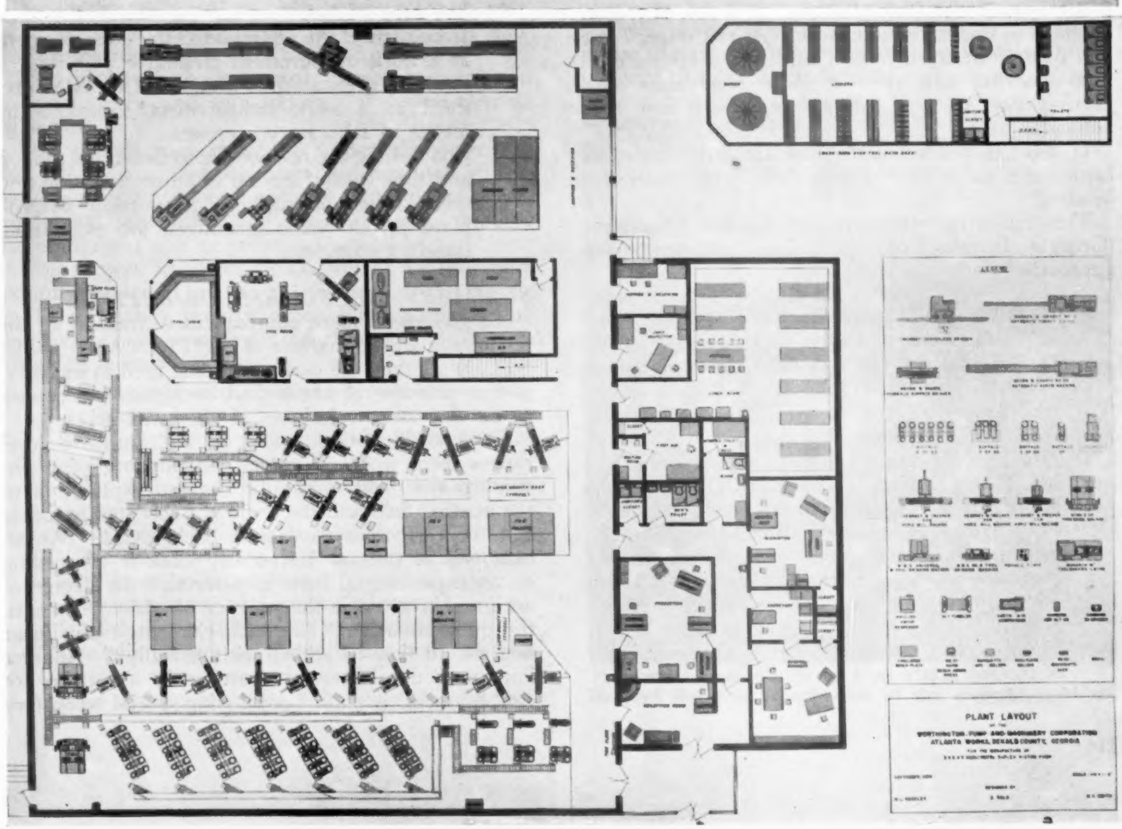
Moreover, it was found that the subject enthused students through the reasons given above and such enthusiasm—no mean attribute—was demonstrated by the time devoted outside formal work to it.

At the Case Institute of Technology, the subject was enriched by the provision of a model room whereby students could build three-dimensional model layouts.

4. 2. 5. *Time and Motion Study*

This subject is a key subject in all courses in industrial engineering and many of the courses had their


PLANT LAYOUT


PLANT LAYOUT
WORTHINGTON PUMP AND MACHINERY CORPORATION
ATLANTA WORKS, DEKALB COUNTY, GEORGIA

Harvard University, Mellon Building.

origin in it. Thus it forms an important 'tool subject' in the equipment of an industrial engineer. Academically it is considered very important as an area which imposes a strict mental discipline and as encouraging logical and analytical thought.

Time and Motion Study occurs in all undergraduate courses and therein lies a difference from the general practice in Great Britain. (It is not, of course, confined to undergraduate work). *At this stage, Time and Motion Study is treated as a tool subject alongside Statistics and even a short observation and participation showed that this approach was very valuable.*

It also has a direct and important link with plant layout and materials handling (see Notes under this heading).

The following statement of Course Objectives (Georgia Institute of Technology), illustrate the approach.

GEORGIA INSTITUTE OF TECHNOLOGY
Tabulation of Course Objectives

1. Introduction to the historical development of MOTION AND TIME STUDY, and Industrial Engineering, as developed from the early work of Taylor and Gilbreth.
2. Development of a broad philosophy of MOTION AND TIME STUDY and an appreciation of its applicability in diverse fields.
3. Coverage of the theoretical background of the motion study techniques of process analysis, operation analysis, machine utilization analysis, micro-motion study, and multiple-activity analysis.
4. Practical application and use of the techniques of motion study by case studies and laboratory exercises.
5. An understanding of the principles of motion economy as related to the use of the human body, arrangement of workplace layout and the design of tools, jigs, fixtures and equipment.
6. An introduction to Methods-Time-Measurement as an extension of micro-motion study and quantitative motion study technique.
7. Practical application of Methods-Time-Measurement as a technique for quantitative motion study by means of laboratory exercises and case studies.
8. To develop "Motion-Mindedness".
9. To develop imagination and objectivity.
10. To develop a pattern of systematic problem solution by use of "The Scientific Method" to solve case study and laboratory problems.
11. To develop a full appreciation of the "Human Factor" in our industrial society, particularly as related to MOTION AND TIME STUDY activities.
12. Coverage of the theoretical background of WORK MEASUREMENT or TIME STUDY techniques, including direct time study, elemental standard-data, and basic data procedures, the use of the stop-watch and other timing devices, written standard practice and methods description, elemental breakdown, performance rating and objective rating, calculation and application of allowances, production and ratio-delay studies, standard time determination, and statistical work measurement control.
13. Practical application and use of the techniques of work measurement by laboratory exercises and case studies.
14. Introduction to Methods-Time-Measurement as a work measurement technique.
15. Practical application of Methods-Time-Measurement as a work measurement technique by means of laboratory exercises.
16. Establishing the relationship between the motion and time study function in an organisation and other functions such as production control, plant layout, wage incentives, job evaluation, standard costs, etc.

SUMMARY OF COURSE OBJECTIVE:

To give the student comprehensive training in the techniques and procedures of MOTION AND TIME STUDY as they are currently being used in industry, and to provide the theoretical background necessary to develop new techniques as the need arises.

Time and motion study at the graduate level ranges from work on special assignments, often involving new fields of application, to exploration of the existing field and the testing of accepted practices against a rigorous analytical background. As an example, at Cornell University, work is proceeding on an experimental basis to determine the degree of accuracy involved in the practice of adding elements, the question being "Are such elements truly linear and should they be added arithmetically?" Another important development occurring in a number of establishments is that of developing special laboratory

apparatus to be used in the measurement work elements and motion elements.

The management area and problems arising from implementation of time and motion study techniques is an important part of the whole field, and is very thoroughly covered.

It appears, however, that the practice in the U.S.A. of presenting analytical techniques—*as techniques*—to be used as tool subjects in other areas of undergraduate study is worthy of the most serious consideration in the development of courses in Great Britain. It was generally agreed that management aspects in the use of techniques such as time and motion study should receive very thorough treatment, but whilst this might best be deferred until students had achieved some degree of maturity, the *technique* was essential to the full development of other subjects which lay partly or wholly in the technological areas.

4. 2. 6. *Project Work*

It has already been stated that the study of plant layout and materials handling involves some project work. There are, however, more general considerations of such work, which are worthy of the closest study in view of the importance of the subject—or practice. At Cornell University, where the curriculum requires *5* years for the baccalaureate degree, a project is required of all fifth-year students. The aims of such work are :-

1. Correlation and integration of the previous four years' work.
2. To emphasise the technical, functional, organisational and personal relationships of modern industry.
3. To provide a *real* problem in which the student would be working under his own initiative and using his own creative ability in design.

The third objective necessarily demands the closest co-operation by and with industry, if the problem is to be real.

One project studied by the writer, demonstrated this fully as the company concerned provided all the data concerning sales, inventory, costs, designs and production schedule of all products made through the equipment and organisation available.

The project involved an assessment of the total circumstances incident on the proposal to fill a gap in the company's product time. The complexity of the project will be appreciated from a study of the following questions :-

1. Can the proposed design be produced in quantity economically?
2. Will the product compete with others already on the market?
3. What will be the selling price for maximum return?
4. What sales media are required?
5. What effect will the introduction of this product have on other lines?
6. Are manufacturing facilities adequate?
7. Is re-design necessary for standardisation?
8. Can the project be financed internally or will external sources be necessary?

Projects are not easy to administer and supervise. Staff must take a group of students who have been given academic skills and through the problem make the students apply *all* their knowledge to a practical situation.

True projects cannot be limited to one aspect of a problem; the object of the undergraduate curriculum is (a) to produce men who are trained in the basic skills for future concentration on research aspects such as occur in graduate schools, or (b) to provide the individual with a balanced aptitude which will enable him to become a useful member of an industrial team.

(The writer received the utmost co-operation in the work of assessing projects and has copies of projects, a study of which is necessary to really appreciate their nature and the students' contributions).

Reference :- Project Work for Industrial Engineering Students, by Byron W. Saunders, Cornell University, Ithaca, New York.

Paper presented at the Annual Meeting of the A.S.M.E., 1951.

5. Development of Studies in Industrial Engineering in Great Britain (College of Technology)

5. 1. *Some Important Considerations*

It has been stated earlier in this report that the project revealed no area of study which is not being covered either as a direct equivalent or a related study in Great Britain.

It did reveal, however, differences in approach and development which are enumerated below as worthy of the serious attention of those in education charged with the development of studies and those in industry whose duty it is to support sound development, in the interests of both the individual and the corporation.

Harvard Business School—one of the graceful buildings.

5. 1. 1. *'Growth and Recognition'*

The provision of courses in industrial engineering —*conceived as a whole and having an individual characteristic and attracting recognition,* is expanding in the U.S.A.

5. 1. 2. *Level of Study*

The growth of industrial engineering studies embraces both undergraduate and graduate levels.

5. 1. 3. *Industrial Aspects*

Industry supports and provides the incentive for such development through opportunities for training, employment and advancement of those with such a course background.

It is fair to state, however, that no *special* preference for an industrial engineering background was evident in the small but representative section of American industry covered by the project.

Industrial engineering courses were accepted in their own rights as an area of study of individual and hence recognisable characteristics, as providing a suitable background for primary employment in those areas associated with the analysis of the manufacturing and service functions.

It was also recognised as providing a correct and useful discipline for those having executive potential and who would eventually reach positions involving decision making on the basis of Industrial Engineering studies and practices.

No 'exclusive rights' were claimed for industrial engineering other than those inherent in the regard for it as an essential and vital function complementary to other functions which vitalise a firm or an industry.

In particular, it attracted high regard as a subject which by its very nature, co-ordinated technical and managerial activity.

5. 2. **Analysis of Possible Areas of Development**

Before setting out suggestions for the development of industrial engineering courses and subjects in Great Britain, it is necessary to redefine the areas under consideration and this is done in the chart below.

In considering developments in Great Britain it is most important to recognise that with few exceptions, *there are few courses which can be called industrial engineering as defined in this report—that is conceived as a balanced whole to embrace the subjects set out above.*

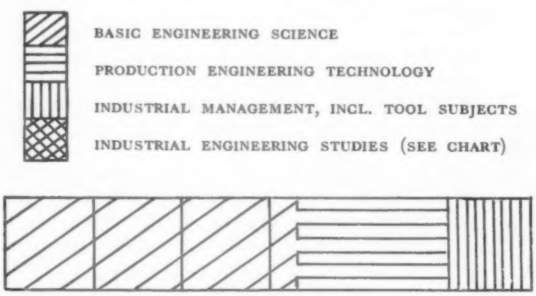
5. 2. 1. *National Certificate Type Courses — Production Engineering and Industrial Administration*

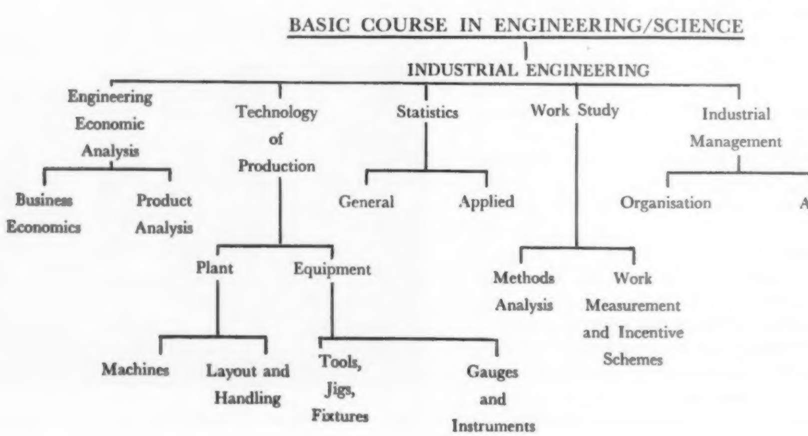
It may be claimed that courses in production engineering and subsequent studies in industrial administration meet the need for studies in industrial engineering.

This is not generally true, particularly when the aspect of co-ordinated planning is considered, and it is important to realise that :-

1. The accepted practice (largely dictated by the examination requirements of the several professional bodies) tends to emphasise (with respect to industrial engineering) the technological aspect.
2. It results in deferring the vital tool subjects of work study production planning and control, layout and materials handling to a stage when they apply to other studies only in retrospect.
3. This results in the great majority of courses producing men who have a good knowledge of the theory and practice of TOOL ENGINEERING but a deficiency in related semi-technical subjects.

The proportion of time devoted to the several areas of study may be portrayed thus :-

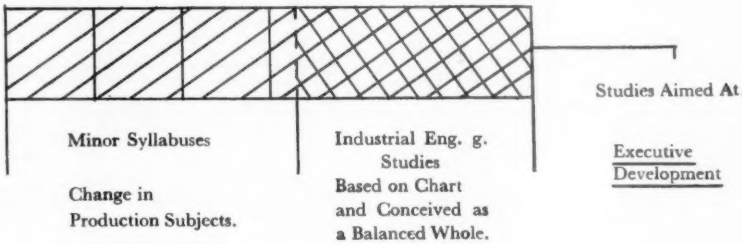




Any modifications to this pattern must be based on a most important premise—

Studies in industrial engineering must relate to fields where it is possible to devise syllabuses and approach which demand a rigorous treatment—mathematical or otherwise.

It is suggested that the above pattern could well be modified—*as a complementary development and not as a replacement—thus* :-



Such a development has been foreseen in the revised 'Notes for Guidance' issued by the Ministry of Education for Production Engineering Courses—except that essential tool subjects are deferred. This warrants some review in the light of the recommendation of this report.

It is suggested that such a development—operating in parallel with the already established courses of a wholly technological nature, would enable a more efficient use to be made of the recognised limited manpower available to industry in Great Britain.

5. 2. 2. *Sandwich-type Courses*
(U.S.A.—Co-operative)

Co-operative Courses were introduced in America in 1906 by Dean Snyder of the University of Cincinnati.

In Great Britain, although this type of course is by no means new, at the present time plans for a much wider development are being made and the support of industry enlisted in those areas where the idea is relatively fresh.

The sandwich course, involving as it does parallel and equal development both industrially and academically, offers an outstanding opportunity for the introduction of industrial engineering studies. Moreover, the time available in such courses is sufficient to allow *project work,* with all its advantages of correlation and self-development of the student.

In discussing such developments during the project, there was general agreement that industrial engineering would demand in the future an increasingly deeper understanding of basic sciences such as physics, since the industrial trend was rapid in embracing applications for the control of manufacturing processes and techniques.

This leads to a general concept that of a four-year course, the first two years should be largely devoted to studies in science, and the chart on the following page illustrates one such approach to the problem.

The chart covers the second two years of such a four-year sandwich course, since the traditional subjects are sufficiently well-known.

It is repeated that in the U.S.A. very great use is made of statistics as a tool subject and not only industrial engineering courses, but some of the older established courses, make statistics a requirement for a degree.

Any development in Great Britain should include this. (See also note in section 4. 2. 2.)

5. 2. 3. *Post-Certificate and Post-Diploma Courses.* (*J.E.*)

A rigid and widespread increase in provision and support for such courses is recommended most strongly.

It was evident, from the naturally limited study made, that much of the success of the American industry depends upon a rapid translation of scientific discovery and of new techniques into the industrial arena, and hence into actual production. Such activity brings with it problems in technology, method, human relations and management.

Management uses 'Industrial Engineering' as a tool in all fields and it is suggested that advanced courses — either as formal courses or as limited specialist courses — should be used as a means of

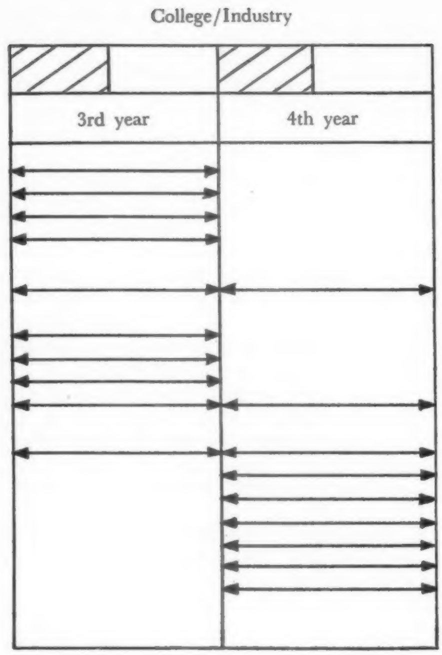
Subject

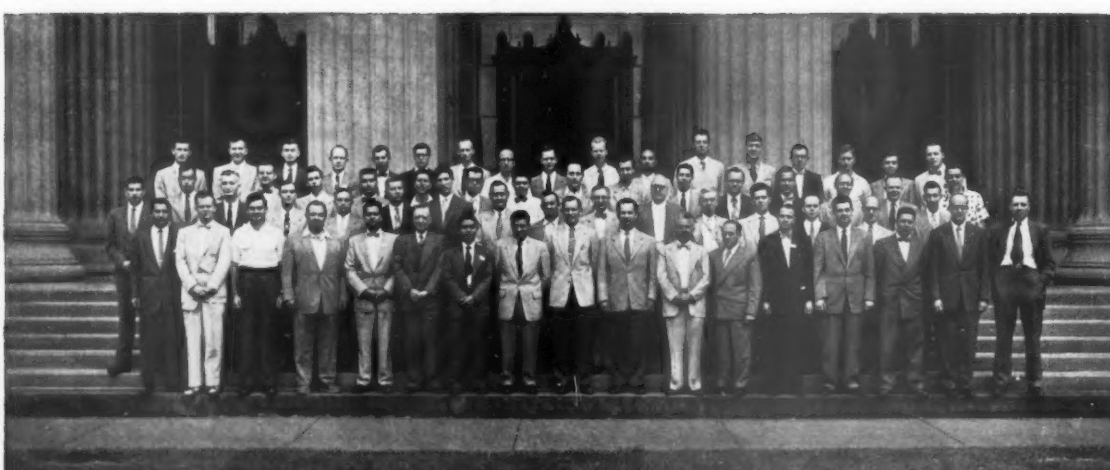
Mathematics.
Statistics.
Work Study.
Electronics.

Materials (covers Strength, Properties and Metallurgy).

Machines (Mechanism and Vibration studies).
Mechanics of Fluids.
Technology of Production.
Factory Organisation and Costing.

Design and Application of Production Equipment.
Measurement and Control of Quality.
Product Design Analysis and Economics.
Production Control.
Management Principles and Practice.
Industrial Psychology.
Plant Layout and Materials Handling Projects.





Massachusetts Institute of Technology Summer Programme
"Numerical Control of Machine Tools" Group.

keeping abreast of the rapidly expanding industrial technologies.

'Automatic Production' — wholly or in part — is receiving attention as this report is being written. The essence of such activity is 'balance'—in material, processes and methods.

5. 3. Related Professional and Industrial Aspects

In Great Britain, corporate membership of a professional society is regarded as a hall-mark of competence, and implies academic and practical ability, associated with a high degree of personal responsibility.

It follows, therefore, *that if studies in industrial engineering are to develop, professional bodies (appropriate) must give them this support.*

On the other hand, such studies must be of such a calibre as to warrant and attract such support.

An analysis of the examination structure of the relevant bodies shows that the requirements are:

(a) wholly 'technological';
(b) wholly 'managerial';
(c) about two-thirds technological and one-third managerial.

It is fully realised that the term 'Industrial Engineering' may not attract full support in Great Britain. This is of little consequence compared with the fundamental concept that:-

balanced courses, conceived as a whole with similar content to that outlined, should receive the utmost consideration from all those party to the development of technical education in Great Britain.

Such courses should be judged whole and not subject by subject against existing yardsticks which were designed to measure performance of a different character.

This report now passes to the related industrial field which was studied as the necessary area for practice in Industrial Engineering.

6. PART II — THE INDUSTRIAL FIELD

This section of the report is designed to illustrate aspects of industrial engineering practices which are not covered by the A.A.C.P. Report, one in particular being the training function.

6. 1. Industrial Engineering Organisation Patterns

The organisational patterns in industrial engineering in America are very diverse. Different units in the same company may have quite differently organised industrial engineering departments.

Again, other large groups may have a centralised organisation which provides a service to the individual plants, and which may or may not provide a training function.

As in Great Britain, the size of the company or group influences the nature of the industrial engineering organisation—ranging from the elaborate, involving many personnel, to the simple, involving one maid of all work industrial engineer.

It is thus important to realise that the industrial background in America relative to the educational background of industrial engineering is in many respects not unlike that in Great Britain. The following examples which were studies have been chosen to illustrate the above general comments so that appreciation of the important industrial engineering 'climate' may be made.

6. 1. 1. *Industrial Organisation at Eastman Kodak Co., Rochester, New York*

This famous company comprises ten plants covering related but diverse products. Co-ordination, particularly of training activities, is through Kodak offices in Rochester where 2,500 persons are employed.

This report is only concerned with the activities at Kodak offices, Kodak Park (Film Processing) and Camera Works, all situated in Rochester.

Industrial engineering was introduced into the Company in 1906 and built around personalities who were associated with Taylor, Gilbreth and Merrick.

Kodak Park. Film Process

At this plant, employing about 20,000 people, approximately 50% are on *Measured Work*. Industrial engineering is envisaged as

METHODS AND WORK MEASUREMENT

and some idea of the personnel involved in this work is evident from the following figures:-

Industrial Engineering Department ...	300
Industrial Engineers	250
Clerks	50

The personnel is representative of 129 American Universities. The areas covered by industrial engineering are shown in the following table.

Manufacturing Methods.	Visual Aids.
Layout.	Statistical Analysis.
Packaging.	Suggestions.
	Package.
Equipment Studies.	Specifications.
Product Development.	
Product Materials Studies.	Industrial Engineering.
	Training.
Plant Housekeeping.	
Product Design.	Industrial Engineering.
	Development.
Safety Studies.	
Communication.	Packaging Laboratory.
Studies.	Model Shop.

The senior executives concerned with industrial engineering in this company have made a careful assessment of the value of industrial engineering courses and have concluded that:-

(a) industrial engineering studies provide a good base material for supplementary training in the plant;
(b) such studies equip a man for administrative work in a better way than the more traditional courses;
(c) industrial engineering is used as a general training for line and staff personnel who

eventually move to other units within the organisation ;

(d) industrial engineering studies are useful for shop personnel in all areas.

The company provided the following analysis of industrial engineers (13 period) and is very pertinent to this report which throughout has stressed the value of a non-standardised approach to the design of courses.

IN-PLANT TRAINING IN INDUSTRIAL ENGINEERING (KODAK PARK)

The following brief outline shows the pattern of the industrial engineering training given in the plant :

1. Indoctrination.
2. Time Study Courses.
3. Methods Engineering.
4. Plant Layout and Materials Handling.
5. Statistics S.Q.C. Work Sampling Methods.
6. Packaging.
7. M. T. M.
8. Human Relations — (includes development of ability to 'sell' industrial engineering. It was considered that this aspect was not stressed sufficiently in I.E. Curricula).

The above course is excellently documented and such material must be studied in detail to appreciate the nature and thoroughness of the approach.

Camera Works. Eastman Kodak Company

In this plant, the organisation does not embrace a separate Industrial Engineering Division (compare previous notes of Kodak Park where a study and separate division exists).

The policy is to allow the industrial engineering function to permeate the organisation, in certain major areas, although organisationally separate, as a limited group make up the industrial engineering function. Production engineering is very strongly developed in the Production Division and is concerned with Methods.

The following charts illustrate the approach and the size of the organisation embraces 4,000 employees.

Generally, industrial engineering in this company is envisaged as embracing three major areas of activity, and great stress is laid on co-ordinating lines of communication between the three :-

Production Engineering ;
Wages and Incentives ;
Control of Quality.

The following notes amplify these titles.

WAGES AND INCENTIVES STANDARDS ENGINEERING

Analysis of Grades

Grades	*No. Employed*
Assistant Time Study Engineer Makes individual time studies on simple work and applies standard data.	4
Time Study Engineer Makes time studies on all work ; compiles reports and modifies complete data.	4
Senior Wage Standards Engineer Generally on special assignments but may work with standard data and compile reports.	4
Project Wage Standards Engineer Administrates work measurement system ; directs new applications.	2
Senior Project Wage Standards Engineer Administrates ; originates and is concerned with policy making.	1
Superintendent Wage Standards Engineer Mainly administrates and is responsible to management.	1

Pattern of movement of Industrial Engineers

Wage Administration. → Production Engineering. Tool Management. / Eng. Design. / I. E. (Not necessarily with I.E. degree.)

A constant flow from Industrial Engineering to Management after experience in several functions takes place. *Industrial Engineering is considered a very suitable recruiting area for Management and this policy is carried out.*

Recruitment and Training

Background. No preference is given to graduates with Industrial Engineering Degrees. Nor is there any evidence that such Graduates do better than those with other educational backgrounds.

Analysis of present Staff

Graduates in Industrial Engineering ...	5
Graduates in Mechanical Engineering	4
Graduates in Electrical Engineering ...	3
Graduates in Accounting	1
No degree but practical experience ...	5
Business Administration	1
	19

All the above take additional studies in Business Administration.

Departmental policy is to maintain 60% engineering content.

Aptitude of practical men with no college background is limited but at Kodak Camera Works, *specialist in application of M.T.M. is a man from works.*

IN-PLANT TRAINING

Wage and Incentives Standard Engineers

All entrants follow same pattern :-

1*st Month.* Company organisation and procedures (1 week). Training in motion and time study in Laboratory (3 weeks).

2*nd,* 3*rd and* 4*th Months.* With experienced man on elementary time study.

5*th* - 22*nd Month.* On own but under general guidance of senior man.

Note :- After 3 years of experience, majority of men are passed to other parts of the organisation — except for three or four key men. (See comment

about suitability of this area for management training.)

Turnover from this group is therefore high due to demands from Production Engineering; Design; Supervision; Staff; and Kodak Head Office. Industrial Engineers are considered as *potential junior managers.*

Comments on requirements in University Courses

Engineering background essential but *need not be so detailed* as for *Design Engineers. An engineering approach is desired.*

Following Engineering —

Selection should take into account personality	Work Study Accounting Statistics Industrial Relations Economics — Engineer Base Psychology Manufacturing Methods

Further studies in Business Administration field and including Sales and Marketing would be useful.

Thus an ideal scheme would be to make studies in I.E. at Graduate level, i.e., B.S., or B.E., plus I.E., — M.I.E.

At Kodak, Mathematical ability is used as a yardstick for suitability for Industrial Engineering Function. (Note, however, that at first degree stage, mathematics equals College Algebra plus Calculus 1 and 2.)

Production Engineering Division

Relation to Wage and Incentive standards Engineering is that I.E. determines *Method.* W. plus I.S. apply a *value* to the method.

General Staffing Pattern

Group Leaders. Men with 10-20 years experience and the general balance to have 2/3rds formally trained through College and in-plant training and 1/3rd from production areas.

Senior Production Engineer. Has ability to handle whole product.

Production Engineer. Assists in Manufacturability Studies and less involved work.
(Usually a Graduate M.E. with industrial experience).

Assistant Production Engineer. Generally works with P.E.
(Graduate M.E. without industrial experience).

New men are assigned to a group for 1 to 1½ years and then moved to other spheres concerned with current production as distinct from new developments. Final work is on manufacturability studies at fluid stage of design. Only 35% of the department's time is spent on current production. All design changes are routed through P.E.

(*see sample Analyisis below*)

Comment on Production Process content in University Courses in Engineering.

"Limited to machines for producing capital goods and not related to manufacture of a product".

Quality Control Engineering

This division covers Material—Product—Package.

Again analysis of staff shows no preference for men with University Qualifications in Industrial Engineering.

*Mechanical Engineers	6
Electrical Engineers	6
Mathematicians	3
Industrial Engineers	2
Physicists	2
Optical Physicist	1
Economist	1
Metallurgist	1

*Title according to College graduation.

Special comment on *Statistics Studies.*

An increasing number of Universities are developing this subject as part of *Industrial Engineering Courses,* and Kodak Staff are teaching as visiting teachers.

Sample Analysis of Background of Present P. E. Staff

No. 1.	B.S. in M.E. plus Eng. Econ., M.S.	*Sen. Prod. Engr.*
No. 2.	High School only, Tool making App. plus Tool Designer, plus Process Engr.	*Prod. Engr.*
No. 3.	Technical School. Tool Layout and Estimating.	*Sen. Prod. Engr.*
No. 4.	8 Years Tech. School plus Management Studies.	*Sen. Prod. Engr.*
No. 5.	High School and Tech. Inst. plus University.	*Supervising Prod. Engr.*
No. 6.	B.S. General Engineering	*Project Prod. Engr.*
No. 7.	Tech. School plus App. Screw m/c operation	*Prod. Engr.*

Assessment of the above grades may be made from rates of pay.

Project Production Engineer	9,500 dollars year
Senior Production Engineer	8,216 dollars year
Production Engineer	6,136 dollars year
Group Leaders and Supervisors	10,800–13,000 dollars year

Training

At entry training is given in Photographic Works and the Photographic Industry—14 weeks full-time course. (See brochure.) Followed by 16 weeks course in Statistical Methods at either Rochester Institute of Technology or University of Rochester. (Part-time course).

Statistics — teaching problems

No general agreement appears to exist as to whether Statistics should be taught by mathematicians or engineers. It was thought that the best results would be from a team approach, the mathematician teaching fundamental theory and the engineer giving application.

New Apparatus, Research and Development

Although not specifically concerned with industrial engineering, the transfer from research project to production demanded strong liaison between I.E., and Research and Development.

Comment with specific reference to I.E. Education

(a) College Staff must have frequent periods in industry.
(b) Industry must take more responsibility for advanced training.
(c) Academic staff should do basic teaching followed by periodic seminars with industrialists of advanced level.
(d) Industrial engineering by its nature should be taught at Advanced level—i.e., Graduate level.
(e) Method of approach should be by formal lectures followed by project work on problems submitted by industry.
(f) Two types of I.E. course could be developed usefully. Borad—based mainly on Management and Industrial Relations; Specific—based on technique.
(g) The principle of 'options' should be allowed to produce a balanced flow of men with different experiences.
(h) Co-operative scheme appears to offer definite advantages over full-time schemes as far as Industrial Engineering is concerned.

NOTE:—Relative values of Ind. Reward to Academic Reward in U.S.A.—4. 1.)

6. 1. 3. *Industrial Engineering in Smaller Concerns*

As in Great Britain, industrial engineering in the U.S.A. is not confined to those companies which employ many thousands, but is found in varying degrees in all sizes of establishment. To illustrate this range the following example is given as complementary to the previous example of larger organisations.

Will and Baumer Candle Co., Inc., Syracuse, N.Y.

This company employs about 200 people and produces a wide range of products, the main being ecclesiastical candles.

Industrial engineering is the concern of one engineer whose background is mechanical engineering followed by industrial engineering studies.

M.E., (M.I.T.), and I.E., (Syracuse).

It was evident from a brief tour of the plant that the application of industrial engineering had achieved a marked increase in productive efficiency. This activity embraced materials handling, work study, design of special purpose equipment, packaging and quality control. It is generally agreed that there is opportunity for the application of industrial engineering in all sorts and sizes of organisation and American experience, as exampled above, fully justifies this opinion.

6. 2. Industry — Education Relations with special reference to Industrial Engineering

Relations between industry and education are extremely important where industrial engineering is concerned. During the project, it was observed that these are particularly strong. The material for project work — that is studies involving the complete working out of a new scheme, or the identification of an existing scheme, was provided readily by industrial concerns.

Also, the majority of University staffs who contributed to this study, were in some way associated with industry on a consultant basis. Such work may be wholly administrative or wholly technological in nature, or embrace all aspects of industrial engineering. Industrial examples of such work are :-

(a) Arbitration in industrial disputes.
(b) Plant replacement studies in materials handling with special reference to fork lift trucks.
(c) Establishment of standard times for materials handling.

6. 2. 1. *Special Courses for University Staff*

A further aspect of such relationship is that whereby companies organise special courses of about three weeks' duration in the Summer for University staff. The first week of such a course is spent in general introduction to the Company's policies and organisation, the remaining time being spent on chosen assignments. Each participant renders a full report to the company of his findings and experience.

This practice has some very important characteristics :-

(a) The teaching staff are given an opportunity to report and explore new industrial experiences.
(b) They become well known to the company personnel.
(c) They can collect relevant and up-to-date material for teaching purposes.
(d) The company benefits through the activities of impartial and fresh minds.
(e) A recruitment area is personally established for graduates from the academic institutions.
(f) Useful follow-up processes can be made.

NOTE:—Company pays travel costs and makes a per diem allowance of 2 dollars plus out of pocket expenses of 200 dollars at the end of the course.

In general, the project revealed excellent relations and industrial concerns appeared very generous—typically American—in their efforts to further the teaching of industrial engineering.

7. Industrial Engineering Training Schemes

7. 1. *General Notes*

Such schemes as were studied varied little from those found in Great Britain. It was significant, however, that once the initiation period of a trainee was over, he was no longer considered as purely a learner, but given increasingly more difficult assignments in real problems and his ability to make useful contributions to their solution was used as a measure of his suitability for advancement.

An outstanding aspect of training schemes in general was the excellence of the documentation associated with them. The following is an example of a training scheme which serves a large organisation.

7. 2. International Harvester Company

This company operates a comprehensive training scheme through a centralised department which gives a service to 24 plants.

The department has no powers of direction, each plant having considerable autonomy in the execution of its training programmes. Training covers top supervisory level (foreman grade and above) and special staff conferences.

It is important to state the Company's attitude to industrial engineering and this is indicated thus :-

7. 2. 1. Industrial engineering is considered a *technical function.*

7. 2. 2. It may exist as a single function or as a diversified function dependent upon size and policy of company.

This is interpreted at International Harvester Co., as Interlocked departments of a staff nature involving :

Labour Relations Department.
Wages and Salaries Administration Department.
Standards and Methods Department.
Material Control Department.

7. 2. 3. *Training Schemes*

Three major schemes are operated :-

5 year Co-operative Scheme.
Progressive Student Courses of 2 years.
On-job product engineering.

General Requirements for Industrial Engineering Training

College degree (if obtained) may be in Mechanical, Civil, Electrical or Industrial Engineering.

Students from I.E. Courses appear to be more 'training minded' than from other courses

The executive in charge of Students and Methods Department expressed a preference for industrial engineers with a high level of attainment in general mechanical engineering education and considerable industrial experience.

Range of Training

College graduate to have :-

(a) 3 to 4 years in production processes including machine tools.

(b) Subsequent training in mechanical engineering, plant engineering standards and budgetary control. This subsequent training to include methods engineering, planning and processes, tool design.

7. 2. 4. *Publications*

To give point to the comment that Training Documentation appeared outstanding, the following is a list of Harvester publications :

Your Career Opportunity after Graduation.
Apprenticeship Course—Manufacturing Works.
Leadership Courses—Manufacturing Works.
Engineering Orientation Course — Engineering Department.
Progressive Student Course — Engineering Department.
Co-operative Engineering Course—Engineering Department.
Progressive Student Course — Manufacturing Works.
Time Study Training Course — Manufacturing Works.
Outline Courses for Works Foremen.
(Company operates a separate school for this.)

Instructional Courses and Lessons

Beating Competition with Quality Control.
Manufacturing Cost Accounts.
Materials Handling.
Waste Reduction I and II.
Longer Life for Cutting Tools.
Standards.

It is convenient to indicate the place of industrial engineering in such an organisation as International Harvester by considering the following proposals for a reorganised scheme which was contributed by Harvester Research Corporation—a control service.

"The Industrial Engineer should be so trained as to co-ordinate the work of PLANT ENGINEER; MECHANICAL ENGINEER; METHODS ENGINEER; STANDARDS ENGINEER."

(*see diagram overleaf*)

7. 3. A Further Example of a Training Scheme in Industrial Engineering. Delco Inc., (Division of General Motors)

In this Company, industrial engineering serves as a function under the Supervisor of Manufacturing Facilities. It is interpreted as METHODS, TIME STUDY, and PRODUCTION SCHEDULING.

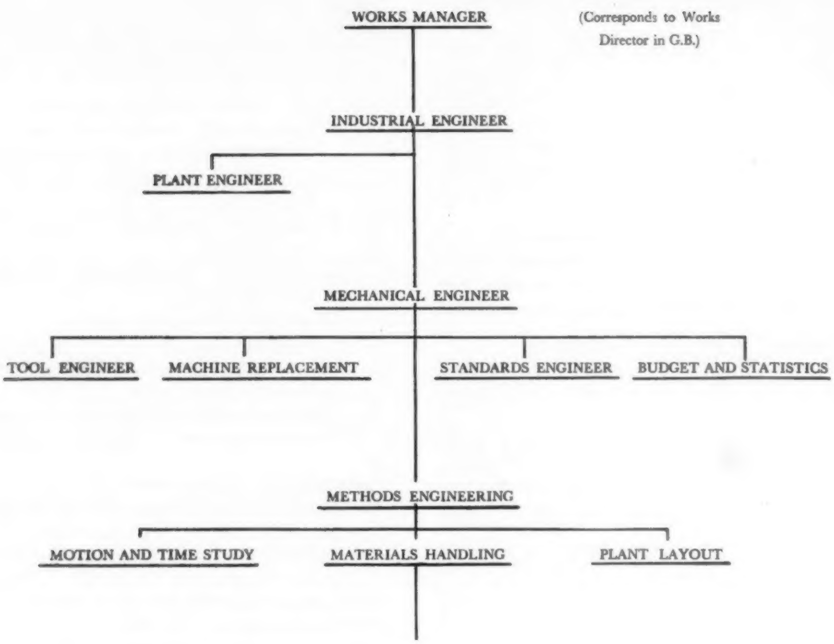
Industrial engineering is considered as a training area for supervision and it is the practice to assign an industrial engineer to the top executive in each working area, thus giving a service in that area. The approximate ratio in General Motors Corporation as a whole is :-

Methods Engineer/Production personnel 1/1000.

(This approximates to the ratio of 1/800 which was assessed for the whole of American Industry in 1950).

Preference is given in the industrial engineering function for Graduates with I.E. degrees and the opinion was expressed that such men have a better concept of Cost and Time than those with straight technological degrees.

The following is an example of a 'tailored' scheme of training for a University Graduate.



IN-PLANT TRAINEE INDUSTRIAL ENGINEER
PENNSYLVANIA STATE UNIVERSITY

Period	*Assignment*	*Weeks*
1.	Inspection	2
2.	Delco Heat Manufacturing Area	2
3.	Split Phase Motor Manufacture ...	1
4.	Heat Motor Manufacturing ...	2
5.	Tool Engineering	3
6.	Product Engineering	3
7.	Industrial Engineering	3
8.	Process Engineering	3
9.	Plant Layout	3
10.	Personnel	1
11.	Maintenance	2
12.	Production Control	2

The training is laid down as consisting of working on assigned jobs as well as observing. In the first four assignments, it covers all phases of the operations, from machining, through sub-assembly, final assembly, inspection and shipping.

Each trainee has to submit a report on his activities and observations at the end of the 4th, 8th and 12th periods.

(It is significant to comment that on Graduating, an industrial engineer at this company received 28 offers of employment—such was the demand for industrial engineering personnel in the U.S.A.).

8. Summary and Recommendations

The experience gained from this project was of the greatest personal value to the participant. Such experience clearly embraced much detailed work and study which cannot reasonably be included in a report of normal length.

The following summary and recommendations are therefore mainly concerned with broad issues of policy and development and it is hoped that they will provide guidance in the implementation of any schemes which result from a study of this and other reports.

8. 1. Industrial engineering and management refers to a co-ordinated area of education and training in which subjects from the technological field and management areas are grouped to form a balanced course of study or programme of training.

8. 2. As a function, industrial engineering is primarily of a staff nature providing a service to line management in two major directions concerning responsibility for :-

8. 2. 1. the evaluation and specification of the physical requirements for the manufacture of a product or the provision of a service

and

8. 2. 2. the development and application of 'tool' subjects, which may be mathematically based or otherwise, used by management in the direction, measurement and control of all processes and methods.

8. 3. It is considered vital to the industry of Great Britain that the practice of industrial engineering should permeate all manufacturing and service activities, irrespective of the size of the organisation or the nature of the product.

8. 4. The industrial engineering area has proved itself in the U.S.A. as a valuable training and education function for those who have personal characteristics which fit them for the direction and control of the work of others. It should be so considered in Great Britain.

8. 5. The foregoing leads immediately to the question of education and training. To achieve the expansion of industrial engineering personnel implied, courses framed within the outline of this report should be developed in Colleges of Technology and Universities.

Such courses should be :-

8. 5. 1. On a part-time basis.

8. 5. 2. 'Sandwich' Courses—these offer great possibilities in industrial engineering due to the dynamic nature of the studies.

8. 5. 3. Full-time post-certificate and post-graduate.

8. 5. 4. Special courses dealing with specialised aspects of subjects.

Without in any way implying restriction, it would appear most practical on all counts, to foster development immediately in those Colleges of Technology which already have strong courses—hence staff—in production engineering and industrial administration.

8. 6. In any development, the engineering approach should be preserved, as it has been found that this is the most satisfactory and indeed logical basis for industrial engineering activity, and through it problems in less technical areas may be developed and solutions achieved.

8. 7. Any expansion of courses will depend upon the availability of staff with the background and initiative to pioneer such courses. Special staff training courses should be developed in areas selected for the penetration of the subject already achieved in both education and industry.

8. 8. In addition to staff training facilities in Great Britain, there is a clear case for a considerable expansion of interchange of teachers between Great Britain and the U.S.A.

8. 9. Professional Societies have a very real responsibility concerning the development of facilities for the study of industrial engineering. Unless adequate *support* and *recognition* are given to the subject as a whole by the professional engineering societies, the development is likely to suffer considerably.

This is a most important issue in view of the considerable influence on educational development which is centred in the professional societies of Great Britain.

8. 10. Industry should continue and expand its association with technical education and this is particularly vital to industrial engineering studies which should draw on industry for dynamic material for use in courses.

8. 11. As regards the training function in industry, industrial engineering, as envisaged in this report, can be the basis of executive development programmes and *in certain cases*, assignments within the industrial engineering function might well be considered as alternative to some of the assignments of a more fully technological flavour at the post-certificate and post-graduate level.

9. Acknowledgments

During the course of this six months project, the participant received innumerable acts of kindness from so many of the American people that it is indeed difficult to express adequately a due measure of thanks.

Merely to list all those who contributed to this work would be in itself a major task.

To all of them, I express my heartfelt thanks, not only for their official help but also for providing those essential comforts which make a long period away from home bearable.

It would be less than just, however, if specific thanks were not expressed to those who throughout the project or for considerable periods thereof, were charged with my well-being, and I thank the undermentioned most warmly :-

Stewart M. Patterson—Foreign Operations Administration, Washington, D.C.

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ROLLED EXTRUSION OF THIN-WALLED PARTS

by W. N. PARKER,

Development Engineer, Tube Division, Radio Corporation of America.

This Paper was presented at the 22nd Annual Meeting of the American Society of Tool Engineers, and is reproduced by kind permission of the Society.

THE Uniskan Extrusion Process, with which this discussion will be chiefly concerned, simplifies the making of fragile, cylindrical parts having wall thicknesses of 0.001″ or less. This process is easily executed and involves simple tools mounted in a drill press. The extrusion operation is followed in some cases by a chemical etching process.

Typical Cylindrical Parts

One recent tube design called for a tubular electrode support having a seamless foil-like wall only 0.001″ thick (Fig. 1). Another design required a one-piece grid structure consisting of hair-like strands joined to cylindrical supporting members. Both parts seemed practically impossible to make with conventional metalworking processes.

The 0.001″ wall tubular part (Fig. 1) is used as a heat-isolating support for an indirectly heated cathode in an electron tube. Heat isolation is further enhanced by making the part of Kovar, an alloy having relatively poor thermal conductivity. Kovar is commonly used for glass-to-metal seals and has the composition 53% iron, 29% nickel, and 17% cobalt. The thicker end portions of the part strengthen the foil-like cylinder and permit it to be joined to the cathode by radio-frequency induction welding.

The making of the part consists of several simple steps (see Fig. 2). A short tubular work blank is slipped over a mandrel. Mandrel and work blank are rotated, and adjustable rollers are fed into the work blank to within 0.001″ of the mandrel. Spacing of the roller from the mandrel determines the thickness of the thin wall. A small axial force is next applied to the rotating work blank, forcing the metal through the rollers to form a foil-like tube closely fitting the mandrel. When the thin wall has been rolled to the desired length, the axial force is removed, rollers backed off, rotation stopped, and the finished part slipped off the mandrel.

The equipment used for this process is relatively simple (see Fig. 3). Rotational and axial forces are provided by a small drill press. The mandrel rotates in a separate bearing and has a toothed collar to drive the end of the work blank. The frame carrying the rollers is self-centering and has an adjustable screw for determining the wall thickness of the thin-walled tubing. Three rollers are used, two fixed and one adjustable; all are mounted on precision needle bearings. The rollers are 1″ diameter. Sixteen needle bearings, 0.0625″ diameter, are used. The photograph of the roller fixture (Fig. 4) shows the frame carrying the two fixed rollers, and a third which may be adjusted during operation by means of a feed screw. Lock nuts on the feed screw may be adjusted to determine the finished wall thickness automatically.

One unusual feature is that a large reduction in wall thickness can be achieved in a single pass through the rollers; for the part in Fig. 1, the reduction ratio was greater than thirty to one. This order of reduction is believed possible only with extrusion of some sort, in which plastic flow is due to hydrostatic pressure set up in the unprocessed material.

Fabrication Process

The action taking place during extrusion may be better understood by referring to Fig. 2. The outer face of each roller has a bead of small radius. As this bead is forced radially into the rotating tubular work blank, the work material tends to "squeeze out" each way along the mandrel. Application of a relatively small additional axial force from one direction causes practically all of the "squeeze-out" to take place on the opposite side of the roller.

When the roller has been fed into the work to the desired spacing from the mandrel the axial force is increased somewhat, causing new material to be forced under the bead of the roller to form additional thin tubing. A shoulder on the roller face is helpful in maintaining a fairly high pressure in the local region immediately behind (to the left of) the roller bead. This pressure helps constrain the very small volume of metal between the bead and mandrel at their closest point. This small volume is tangentially constrained by the elastically compressed metal immediately ahead and behind by the exceedingly small volume undergoing extrusion at any one instant. These localised geometric volumes are then thinned out or scanned through the work material in helical patterns, with the result that the thick-walled blank is forced out into a thin-walled cylinder without loss of material. This process, as a "single-scan extrusion", was named Uniskan.

Another characteristic distinguishing this process is the application of all forces required to accomplish forming through the relatively thick work blank. After the material has been thinned, it need transmit no forces whatsoever. This characteristic is in sharp contrast to metal spinning, in which practically all driving forces are transmitted through material which has already been thinned. Ultimate wall thinness which may be achieved with spinning and turning methods is severely limited by the lack of strength of the partially thinned material. With the Uniskan extrusion process, however, in which the driving forces are all transmitted through the thick blank, it is relatively easy to obtain tubular members several inches long having wall thicknesses of less than 0.001″.

Grid structures for electron tubes, which must fulfill certain functional requirements, are made by a slight variation in the process used for thin wall tubing. Good tube performance required a grid structure designed to keep the grid wires cool. One such design consists of a cylindrical array of straight fine strands formed integrally with relatively heavy tubular end support members. The 60 grid wires are each 0.005″ wide. Elimination of welds or other joints materially aids conduction of heat away from the grid strands. Cooling may be further enhanced by the use of oxygen-free high-conductivity copper in the one-piece grid.

Fabrication of a one-piece grid by Uniskan extrusion differs from the thin-wall tubing procedure in two respects. First, the mandrel must be provided with longitudinal grooves which determine the number, size, and shape of the grid strands. During the pass through the rollers, material is forced into these grooves. Both grooves and surface of the

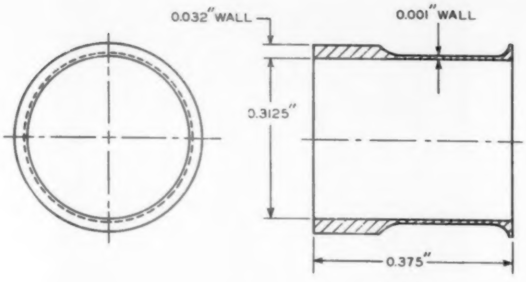


Fig. 1.

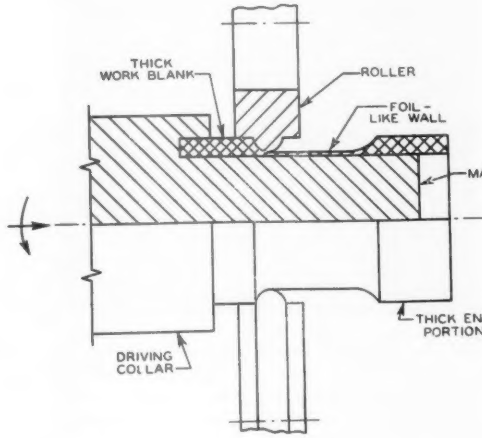


Fig. 2.

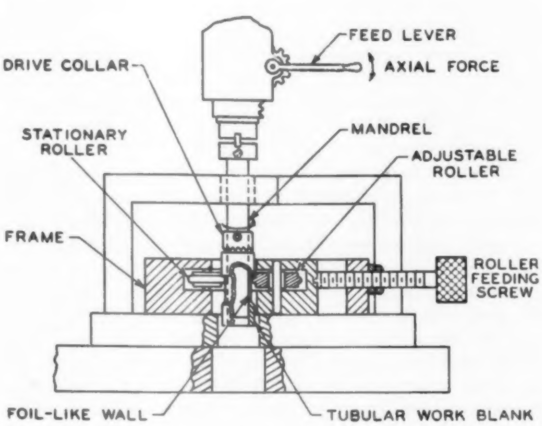


Fig. 3.

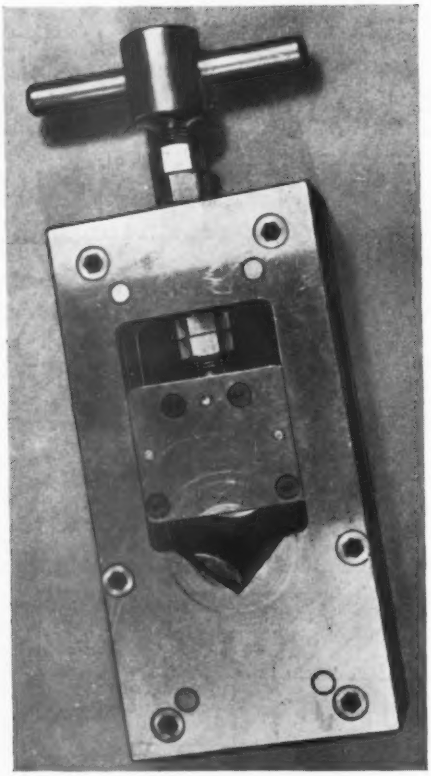


Fig. 4. A frame carries two fixed rollers and a third which may be adjusted during operation by means of a feed screw. The highly polished rollers turn on precision needle bearings.

mandrel are ground to a smooth finish. The part as taken from the mandrel is shown in Fig. 5 and consists of a cylindrical array of ribs connected by a foil-like webbing. Removal of the webbing yields the desired grid.

The web is removed by dipping the part in an etching bath for a few seconds. The interconnecting web disappears, leaving an accurately formed grid structure free from stresses which might later cause deformation.

In spite of the delicate nature of this grid structure, the part may be readily handled by means of the heavier supporting portions. The portion of the support just below the grid strands is formed into an accurate cylindrical jigging surface by an additional step in the Uniskan procedure. After the desired length of grid strands has been formed, the rollers are partially backed off and the axial feed continued for a short distance. The length dimension of these steps may be controlled by a series of stops which actuate microswitches. These, in turn, light lamps which signal the operator when predetermined lengths have been achieved.

The work blank for this grid is a drawn cup consisting of two sections of different diameter. Its length is somewhat shorter than the finished grid to allow for the elongation during extrusion. Grids made by this method are better and cost only a fraction of older types made by hand-threading and spotwelding molybdenum wire to nickel tubular supports.

A larger diameter grid is used as the screen electrode in a 1000-watt tetrode widely used in UHF television broadcasting. In this case there are 180 strands, each 0.010″ wide, formed integrally with the supporting members and end shield.

The one-piece control grid for this tube is similar, but has only a light connecting ring at the extremities of the grid strands. The strands of these two grids must be exactly straight and accurately indexed to provide exact registry with each other in the electron tube. The maintaining of exact shape after long exposure to high temperature is largely due to the weak, uniform residual stress pattern found in parts made by extrusion.

Grid structures made by the above procedure cover a wide variety of designs, one of which consists of tapered slats integrally formed with end rings. The grooves in the mandrel for this grid vary in width at a somewhat greater rate than the desired part to allow for elongation of the work during the extruding operation.

The one-piece grid consists of relatively few coarse grid strands arranged in a slow spiral. During the extrusion process, the partially completed part simply untwists along the grooves in the mandrel. Another design has the grid strands arranged in a zig-zag pattern; the webs were etched out after forming. The mandrel for forming this part is made in three pieces. Initially, the rollers are started over the spiral section remote from the shank of the mandrel and the formed ribs follow the grooves as before. As the work elongates, both spiral sections slide out of the tubular shank.

Mandrel and Roller Design

Mandrels and rollers should be carefully made if high quality parts are desired. Slight roughness or eccentricity may become quite objectionable when wall thicknesses are rolled to 0.0002″ or 0.0003″. Satisfactory mandrels have been made of a chromium alloy steel (2.10% carbon, 0.25% manganese, 0.25% silicon, 12.50% chromium, and 0.5% nickel). The heat-treating consisted of packing in clean cast-iron chips and heating at 1775°F for 20 minutes. After being heated, the mandrels were quenched in oil and drawn twice, each time for 1 hour at 212°F. Hardness measured 64 to 66 Rockwell "C". Each mandrel was then ground to diameter and polished, after which the grooves were ground with a suitably thin wheel mounted between supporting plates. The various thicknesses of grinding wheels down to 0.003″ were supplied by the Allison Company.

The slow-spiral mandrels were ground by utilising a special high-speed belt-driven grinding spindle mounted in a milling machine. Particular care had to be taken to account for back-lash with this set-up.

Accurate measurement of groove depth presented a problem in making a mandrel for a grid having ninety 0.003″ strands. The method adopted utilised an additional portion of the mandrel having a diameter equal to the inside diameter of the finished grid and a slight known taper. As each groove was ground, a mark was made along the tapered section by the wheel. The length of the mark along this taper provided a convenient check on uniformity of groove depth and made it very easy to allow for grinding-wheel wear.

Rollers have been made of a high-carbon tool steel heated for hardening to 1525° to 1550°F. in an oxidising atmosphere for 15 minutes, quenched in oil, and drawn at 300°F. for one hour. Hardness measured 64 Rockwell "C". The radius of the bead, which is not particularly critical, was 0.062″ on a 1″ diameter roller for the type of work shown. It is desirable that the rollers run as true as possible to give a smooth polished finish on extruded parts.

Materials suitable for use with the process range from soft copper to harder materials like molybdenum. A suitable etchant for grids made of copper is a 30 to 50% solution of nitric acid in distilled water. Other metals require different etchants. For example, tantalum requires hot hydrofluoric acid with a trace of nitric acid added.

Fabrication of Cone

An interesting variation of the process is shown in Fig. 6. A flat disc-shaped work blank is mounted on a face plate, which is then rotated. A single roller is pushed against the work and fed radially outward in a single pass. This pass forces thinned material toward the centre to rise from the face plate and form a cone.

The examples described are believed to be but a few of many possible applications of the extrusion process we have discussed. The ease of precision fabrication, the simplicity of the required tools, and the relatively small total forces involved all enhance the attractiveness of this method for making certain kinds of intricate and/or delicate parts.

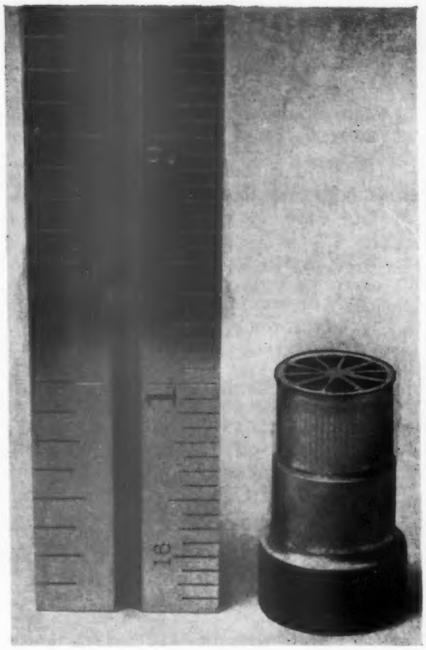


Fig. 5. The partially completed grid consists of a foil-like cylinder having thicker longitudinal ribs along its inner surface. These ribs become the grid strands when the interconnecting foil-like web is removed by etching.

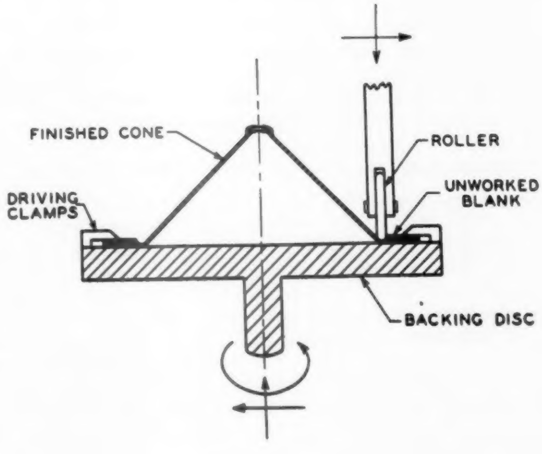


Fig. 6.

THE RESEARCH COMMITTEE OF THE INSTITUTION

ON 11th January last, the Institution, in collaboration with the Institute of Cost and Works Accountants, published a new Report — " Production Control and Related Works Statistics ". This Report is the last of a series of four covering the work of joint committees of the two bodies formed to consider Measurement of Productivity.

The previous Reports are :-

" Measurement of Productivity — Interim Report " ;
" Measurement of Productivity — Applications and Limitations " ;
" Measurement of Productivity — Work Study, Application and Training."

The Research Committee have also been responsible for issuing the following Reports :-

" A Review of Materials Handling in British Manufacturing Industries " ;
" As the Spirit Moves " — Case Studies in Materials Handling
(in collaboration with the British Productivity Council) ;
" Material Utilisation in the Metal Working Industries ".

These and other Reports are the result of field research undertaken by the Research Committee of the Institution. Whilst in this work the Research Committee enjoys the enlisted aid of Sections and of individual co-opted members, other members may not be aware of the breadth of this activity of the Institution. The Research Committee are at the present time engaged in field research under the following headings :-

" Sources of Information "	—	a Guide giving a comprehensive list of sources of information available to the Production Engineer.
" Material Utilisation "	—	Finishing (painting, vitreous enamelling, chemical finishes and plated finishes). Ancillary Materials, particularly with regard to packaging, cartoning and shipping materials. Alternative Materials (e.g., powder metallurgy, plastics, ceramics, etc.). Indirect Materials (e.g., degreasing solutions, wetting agents, lubricants, cutting materials, etc.).
" Control of Quality "	—	incorporated in the design of the product, the design of the tooling, and in the product itself at the time of manufacture.

Further joint research with the I.C.W.A. is soon to commence.

Offers of assistance in this research activity will be welcomed from any members of the Institution. Likewise, the Research Committee would welcome any suggestions regarding subjects for future research.

The Research Committee is established in order to guide the Council on such matters and the results of its work can be of lasting benefit to members of the Institution and — where reports are published — to many individuals and bodies outside the Institution. It is of importance for the Committee to maintain its contact with the membership and in this way with industries and organisations up and down the country and indeed overseas.

The work of field research is constructive and satisfying — witness some of the press comment on the Institution's published Reports :-

" Measurement of Productivity — Applications and Limitations "

" Machinery "	—	'The Joint Committee have undoubtedly performed a valuable service and although the facts brought to light by their investigations, and presented in the last part of the report, are not necessarily new, there is ample evidence to show that they do not normally receive sufficient attention in British industry.'
" Factory Manager "	—	'Coming at a time when the full and efficient utilisation of the resources of production is of the greatest national importance, the report issued by the Joint Committee is of especial interest and value. The need for fuller information about two such important aspects of efficient production as those with which the committee was particularly concerned was revealed by the latter's investigations into the measurement of productivity in firms and industries ; evidence showed that normally British industry pays insufficient attention to them.'

" Measurement of Productivity — Work Study, Application and Training "

" Metal Industry " — 'Implementation of its recommendations would go far in the direction of obtaining more reliable facts about industrial operations and of devising more effective ways of raising output. General acceptance of the syllabus of training would help to raise the standard of work study practice and increase the number of competent technicians. Perhaps the most important need at the moment, however, is the greater realisation by managements of the value of work study and their unqualified and enthusiastic support for the objectives which the Joint Committee's Report seeks to obtain.'

" Times Review of Industry " — 'Bearing in mind that the Joint Committee's principal objective is the raising of productivity, this extension of its investigations to the more comprehensive subject of work study is justifiable. Time study practice in Britain has probably suffered from the tendency to limit its application mainly to repetitive work for the purpose of introducing payment by results schemes. There is, however, a much wider application for time study used as a method of work measurement in conjunction with methods study, motion study and job evaluation, the other techniques described in the report as comprising work study. A firm's productivity is much more likely to benefit from a systematic use of these procedures, with their obvious implications for pre-production planning, efficient operation and effective managerial control, than from an application of time study, perhaps preceded by some motion study, solely in the interests of an incentive scheme. In this way the emphasis is placed on improving methods, reducing costs and setting targets. Clearly both a wider application of work study and the full benefit of its techniques will only be attained through a sufficient number of trained technicians conforming to a recognised level of competence.'

" Material Utilisation in the Metal Working Industries "

" The Ironmonger " — 'While it shows that there can be no golden rule as to which form of semi-finished material will achieve the highest material utilisation, it does point out certain essentials for the achievement of the maximum efficiency and economy in manufacturing processes.'

'The report with its annotated and illustrated case studies is well worth a place on the desk of the manufacturer's executive.'

" Metal Industry " — 'Therefore, any steps that can be taken to ensure that in the manufacture of any particular part, the amount of metal to be removed — and concurrently the amount of scrap produced — is brought to a minimum, are of the greatest importance. For this reason the booklet " Material Utilisation in the Metal Working Industries " prepared by a Committee of the Institution of Production Engineers is worthy of the most serious study.'

" Light Metals " — 'The Institution of Production Engineers report is certain to be widely studied as a source of inspiration to those searching for cost reductions in the more competitive conditions now with us. Economy in materials utilisation will be increasingly sought and even though producers of ingot and semi-fabricated products have no *prima facie* cause for enthusiasm in the matter, it is in their interest to co-operate in it with their customers.'

" Art and Industry " — 'The case studies are particularly meaty and to the point. They have been grouped according to the ultimate process of manufacture (Fabrication, Cold Heading, Hot Pressing, Drop Stamping, Die Casting, Shell Moulding, etc.) and in most a before-and-after technique has been adopted to emphasise the savings achieved, financially, and in man-hours, by planned material utilisation as against the *laissez-faire* approach of which the Report is a condemnation.'

'Although the Report then goes on to add that the problem is not the " exclusive responsibility of the design office ", that it is in fact " everybody's business ", one gathers the impression that the Report is intended, in part at least, as a rap on the knuckles for the shapes-for-shapes'-sake designer, to whom aesthetics and economics remain for ever incompatible.'

"Production Control and Related Works Statistics"

"Electrical Review" — 'Emphasis has rightly been placed on the fact that eight out of ten manufacturers in Britain employ fewer than 100 people, a fact often lost sight of in glib talking on the subject of productivity. The determination of the minimum economic control applicable in small concerns is important and it is in these very firms that a great future increase in productivity is possible.'

'Many of them carry on their activities in old buildings and sometimes with old machinery. In such surroundings and perhaps using rule of thumb systems handed down from the past, the germs of more streamlined techniques rarely flourish. This report will help those in smaller concerns, often responsible for many functions, to recognise the phases of their activities dealing with production control, and from these to finding ways of improvement is but a short step. We feel sure a study of the report's contents will prove useful to some of our readers who often themselves have multifarious responsibilities of this nature.'

"Machinery" — 'Well illustrated and clearly presented, this report can make an important contribution to increased productivity and deserves the careful study of those responsible for management in all fields of industrial activity.'

"Engineering" — 'The degree of production control employed must always depend on the particular application. Statistics can be multiplied beyond useful and reasonable bounds leading to much unnecessary expense. Equally, too few facts can also lead to expense by wastage of time and material, or missed opportunities.'

'Comparatively few facts are needed to maintain a good organisation but the intelligent use of them is vital. These are the points brought out in the report, together with suggested methods for using them in the various operations of medium and small firms.'

The following Reports, mentioned above, may be obtained from the Publications Department, 10 Chesterfield Street, London, W.1, at the prices stated, which include postage:

"Measurement of Productivity — Interim Report" — price 1s. 6d.

"A Review of Materials Handling in British Industries" — price 5s. 6d.

"As the Spirit Moves" — price 1s. 3d.

"Material Utilisation in the Metalworking Industries" — price 5s. 6d.

The following Reports are obtainable *only* from Gee & Co. Ltd., (Publishers), 27/28 Basinghall Street, London, E.C.2:

"Measurement of Productivity — Work Study, Application and Training" — price 5s., post free.

"Production Control and Related Works Statistics" — price 5s., post free.

Production Engineering Research Association of Great Britain

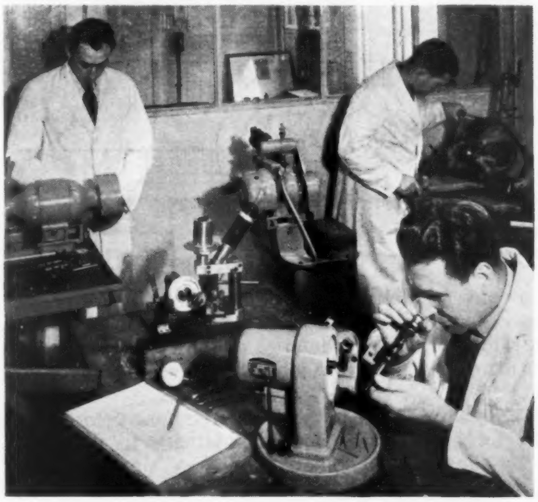
Quarterly Newsletter to the Institution

DECEMBER, 1955

A brief article accompanied by an extensive bibliography on vibration associated with machining operations was given in the October, 1955 issue of the bulletin. The bibliography was divided into sections dealing with vibration of cutting tools, machine rigidity, machine foundations, and information of a general or fundamental character. Factors affecting the selection and use of cutting tool terms and definitions were briefly discussed in the November Bulletin with a view to encouraging engineering firms to state their opinions on the subject. Although British Standard terminologies give some guidance on tool nomenclature, certain practical considerations limit the use of these standards, and it is highly desirable that the terminologies used by PERA should not only be suitable for research purposes, but should be applicable in the workshop, taking into account ease of specification, inspection, and availability of tool grinding equipment. The December Bulletin contained a brief synopsis of the results of PERA's recently completed research on the effect of drill point shape when drilling cast iron. This research showed that marked increases in drill performance can be achieved by employing point shapes other than those commonly used in industry.

Library

Further additions of production engineering literature to the library brought the totals for the whole year to 865 new books, standards, reports, etc., and 3,200 additional pieces of trade literature. The number of loans made to member firms during the year was 7,650, in addition to the supply of about 60,000 copies of the articles abstracted in PERA Bulletin



Part of the drill grinding section of PERA tool and cutter grinding bay.

Technical Enquiry Service

Further increases took place in the very heavy demands on the Technical Enquiry Service. During the year about 1,700 requests were received from member firms for information and advice on a wide range of subjects including, brazing, forging, automation, liquid honing, bonding, storage, shot blasting, motion study, assembly, inspection, surface finish, maintenance, plastic moulding, induction heating, painting and spraying, press tool design, heat treatment, powder metallurgy, shop layout, swarf disposal, barrel finishing, packaging, cold heading, progress systems, die-casting, and many other branches of production engineering.

Research Programmes

Research on " finishing blanking " has continued and is establishing data on the conditions required to produce smooth, crack-free edges on blanked steel components without the need for subsequent shaving or other finishing operations. Corresponding data has already been produced for blanking various non-ferrous materials, and the recommendations for blanking mild steel are being tried out in some member firms. A survey of burr formation and prevention on pressed components such as blanked, pierced and cupped components is nearing completion. The survey includes the results of observations in industry in connection with various chemical, manual, and mechanical methods of de-burring, and is complementary to reports previously issued dealing with the de-burring of machined components. A further report in this series, devoted particularly to barrelling techniques, is also being drawn up.

The practical work has now been completed in an investigation on reaming. The results show the extent to which the accuracy and surface finish of reamed holes may be affected by differences in radial rake and land length on the reamers used. A research into vibration and chatter problems associated with metal cutting operations and machine tools is proceeding.

New researches authorised include : a study of the effects of high speed steel specification on the performance of drills and lathe tools manufactured from various high speed steels; an investigation into the effects of different types of point thinning on drill performance; and a research to establish the effect of die speeds and penetration rates on thread rolling forces and die life.

CASE STUDY No. 3

Unloading Covered Vans

Firm: **The Brooke Tool Manufacturing Co. Ltd.**

Author: **General Manager**

An example of materials handling at goods inwards and despatch points.

The Company. *The Company where this example was applied is a branch works and employs 160 people on the manufacture of high grade engineers' small tools.*

The Source. *This example was the outcome of an idea by the manager of the branch works, where the unloading and loading of small and concentrated loads from covered vans and wagons having permanent covers presented difficulties and dangers.*

The Circumstances. *This branch works has no special department for the investigation of handling problems or the manufacture of special equipment, and the equipment shown in the improved method was home built in the works engineering department to the manager's design. The method used for many years was to manhandle the loads on and off the lorries, presenting a danger hazard to the personnel involved and causing repeated damage to the van roof and floor.*

old method

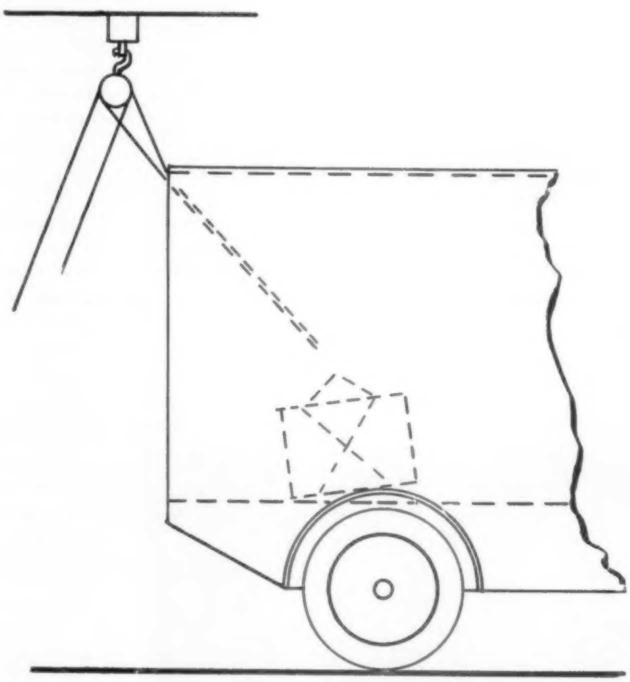
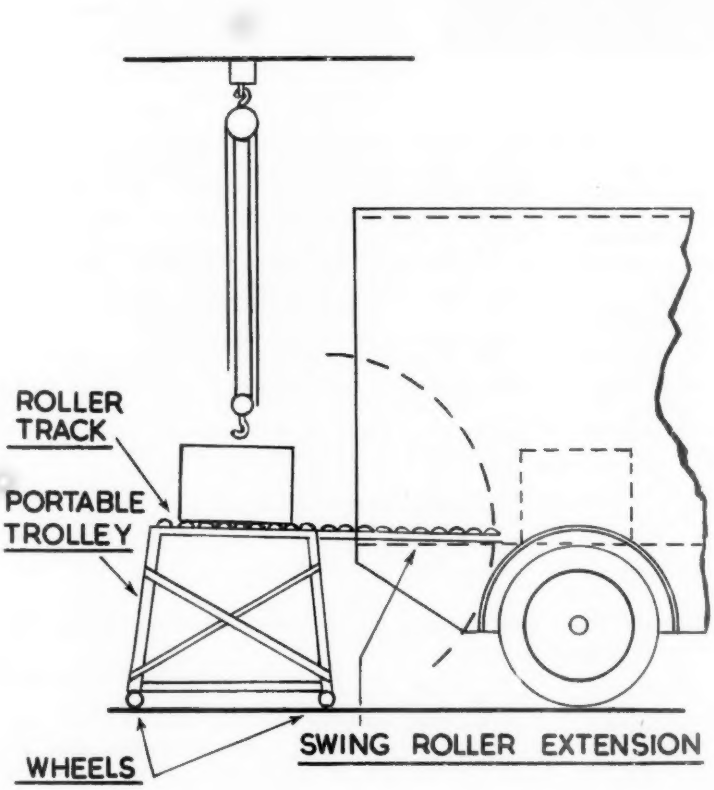


Fig. 1 shows how a conventional hoist in a monorail was used to load and unload the heavy loads. The load had to be swung into the van and dragged along the floor, causing damage to the floor and roof as well as being a very tiring and dangerous job for the personnel involved.

To unload, slings were placed under the load and the hoist used to pull the load along the lorry floor, again causing damage to the floor, and additionally to the roof where the chain or slings rubbed.

HANDLING

new method



The 'home built' equipment shown in Fig. 2, which was built to simplify the loading and unloading problems, consisted of a table on castors equal in height to the highest normal platform of a covered vehicle. The table top is constructed of two lines of short rollers and two swinging arms suspended from one end. In practice, the load is lifted by a normal crane placed on the table, and the table either moved to the vehicle or the vehicle backed up to it.

At the same time, the swinging arms are lifted and allowed to ride inside the vehicle. It is then a very simple matter to push a weighty case, no matter how heavy, inside the vehicle and to make sure that it is well inside before it comes off the rollers.

Where necessary, extra gravity roller track is used to extend the easy run of work on to the back of the vehicle.

Advantage. As well as reducing the danger hazard, considerably less effort is required to load or unload.

The first unit, built mainly from scrap materials, cost approximately £30. The savings resulting from its use were the effectiveness elsewhere of two men who had been intermittently employed assisting loading and unloading operations.

Summary. The unit proved so successful that engineering drawings were made and several more built for wider use within the group. The original was introduced some time ago and is in regular daily use.

The same approach to this problem and others would be acceptable today, and a special study department is not envisaged for concentration of thought or development of ideas since the present system produces quite satisfactory and regular results.

EXTRAORDINARY GENERAL MEETING

Notice is hereby given that an Extraordinary General Meeting of The Institution will be held at 10 Chesterfield Street, London, W.1, on 14th June, 1956, at 2.00 p.m. to transact the following business namely :-

The Council of the Institution in accordance with Article of Association No. 30 recommend that from the 1st July, 1956, the entrance fee and annual subscription for each grade of member of the Institution shall be :-

(a) Entrance Fee

Every candidate, with the exception of Students, Graduates and those entering by examination, shall on election pay an Entrance Fee, the amount of which shall be equivalent to one year's subscription for the grade to which he is elected. No payment, other than the increased annual subscription, shall be due on transference from one grade to another.

(b) Annual Subscription

	Members resident in the United Kingdom	*Members resident outside the United Kingdom*
Honorary Member	Nil.	Nil.
Member	£6. 6s. 0d.	£5. 15s. 6d.
Associate Member	£5. 5s. 0d.	£4. 14s. 6d.
Associate	£5. 5s. 0d.	£4. 14s. 6d.
Graduate	£3. 13s. 6d.	£3. 3s. 0d.
Student	£2. 2s. 0d.	£1. 11s. 6d.
Affiliated Organisation	£10. 10s. 0d.	£10. 10s. 6d.

(for the first representative and each additional representative £10. 10s. 0d.)

(c) Life Subscription

Any Member, Associate Member, or Associate whose subscription is not in arrear may compound for the then current year and all future years on payment of sixty guineas.

By order of the Council,

W. F. S. Woodford,

Secretary.

Retired members

Note:

In accordance with the provision of Article of Association No. 31 the Council have resolved that any member who has reached the age of 60 years and who has retired from substantial remunerative occupation may retain his membership on payment of half the normal annual subscription. Any member who has retired and who has had 15 years or more continuous membership of the Institution may, as an alternative to half rate subscription, compound all future subscriptions on payment of 10 guineas.

This photograph, taken at the Dinner, includes Mr. Harold Burke, Past Chairman of Council; Mr. H. A. Richardson, Reading Section Chairman-Elect; Mr. R. W. H. Mark, Section Hon. Secretary; Mr. F. M. Mott; Mr. W. F. Reid; Mr. F. T. West, M.B.E.; Mr. T. H. Christy, (Section Chairman); and Mr. W. F. S. Woodford.

The Reading Section held its first Dinner for members and guests on the 17th February, 1956 at The Mill House Hotel, Swallowfield, Berkshire. Mr. Harold Burke, immediate past-Chairman of Council and Chairman of the Midlands Region, was Guest of Honour. Other guests included Principal F. T. West, Chairman of the Southern Section, and Mr. Woodford, Secretary of the Institution.

Mr. T. H. Christy, Chairman of the Section and Chairman of the Southern Region, was in the Chair and in welcoming members to the Dinner he said he hoped it would be the first of what would be an annual occasion. Mr. Christy proposed the health of the guests, which was responded to by Mr. Harold Burke. Mr. Burke gave an outline of developments within the Institution over the past few years and congratulated the Reading Section on the progress they had made. He commented on the "Continental atmosphere" of the Dinner which was achieved by the dècor of the room. The effect was heightened by the delightful musical entertainment which was organised by Mr. Tom Mott.

Mr. Woodford presented Mrs. Mott with a bouquet on behalf of the members of the Section in appreciation of her delightful piano playing. Several members and guests made impromptu contributions to the music and revealed an artistic side of production engineers which is not often evident at their meetings.

Institution Staff

Mr. S. Caselton, Deputy Secretary, last month completed 20 years' service with the Institution. He joined the staff in 1936, at the age of 18, as Secretary to the late Richard Hazleton, first General Secretary of the Institution, and served in that capacity until December, 1939.

At the time Mr. Caselton joined the Institution, the offices were housed in two small rooms at British Industries House, Oxford Street, W.1, with a staff of five and a membership of 1,330. The President was the Rt. Hon. Lord Sempill, A.F.C., Hon.M.I.Prod.E.

In 1939 Mr. Caselton joined the Royal Navy and after a short period in the ranks was commissioned. He was engaged in active service at sea in many theatres of war, and at one period served in the Flagship of the First Battle Squadron, Eastern Fleet. In 1944, he was appointed in command of one of H.M. Ships.

On demobilisation in 1946, he returned to the Institution and was appointed Head of the Education and Membership Department. He was subsequently promoted to Office Manager and Assistant Secretary, and in July last year was appointed Deputy Secretary.

The many members of the Institution to whom Mr. Caselton is well known will undoubtedly join in congratulating him on this record of service.

news of members

The President of the Institution, **Sir Leonard Lord,** has been visiting Australia and was able whilst in Sydney to have an informal discussion with the Sydney Section Committee at a luncheon on 21st February last.

Mr. H. Cheetham, Member, has relinquished his appointment with the Gateshead Technical College, and has now taken up an appointment as Principal of the Walsall Technical College.

Mr. James Farmery, Member, has relinquished his position as Principal of the College of Further Education, Workington, Cumberland, and has taken up a position with the Education Department, New Zealand.

Mr. J. Paisley, Member, has been appointed Assistant Managing Director, Production, of the Eastwoods Group of Companies, Ltd.

Mr. K. H. Shute, Member, has left Sydney on a visit to London. Mr. Shute is an active member of the Sydney Section Committee and is Chairman of their Papers Sub-Committee.

Mr. Walter Snell, M.B.E., Member, has recently retired from Ruston & Hornsby Limited, where he was Assistant Works Manager and Production Engineer at their main Works. Mr. Snell has been employed by the Company since February, 1901, and he therefore retires after completing 55 years' service.

Mr. J. M. Steer, Member, is visiting the U.K. Mr. Steer was for many years Honorary Secretary of the Sydney Section since its formation, and he has done a great deal to further the interest of production engineering in Australia.

Mr. Norman G. Sykes, Member, has been appointed Chairman of the N.A.T.O. Sub-Committee on Standardisation of C-Cores and Magnetic Laminations. This is a Sub-Committee of the N.A.T.O. Group of Experts on Electronic Components. Mr. Sykes is Deputy Head of Production, Admiralty Signal and Radar Establishment, Portsmouth.

Mr. Richard T. M. Toyn, Member, was recently elected a Member of the Worshipful Company of Blacksmiths and a Freeman of the City of London.

Mr. F. L. Andrews, Associate Member, has relinquished his appointment with the Ministry of Supply, M.E.X.E., and has taken up a position as a Senior Design Engineer with Benford Limited, Warwick.

Mr. S. R. Chatterjee, Associate Member, has been appointed Works Manager of the Machinery Manufacturers Corporation Limited, at Kidderpore, Calcutta.

Mr. R. H. Davis, Associate Member, of the Sydney Section, left Sydney on 20th February for a visit to South Africa, England and the United States.

Mr. A. E. Dodson, Associate Member, has been promoted to Works Manager of his present Company, Messrs. J. Collis & Sons Limited, Barry, Glam.

Mr. C. W. Hancock, Associate Member, formerly Manager, Spares & Sub-Contract Divisions, North British Locomotive Company, has been appointed Chief Engineer, Wagon Repairs Limited, Birmingham.

Mr. G. Howard, Associate Member, has recently taken up the post of Chief Engineer with Messrs. Tootal Broadhurst Lee & Co. Ltd., Devonport, Tasmania.

Mr. Frederick Johnson, Associate Member, has relinquished his position of Development Engineer with Woodhead Components Limited, Sheffield, to join Samuel Osborn & Co. Ltd., Rutland Works, Sheffield, as Toolroom Foreman.

Mr. W. G. Key, Associate Member, has taken up a new appointment as Works Superintendent at Borg-Warner Limited, Letchworth. Mr. Key was for some time the Honorary Secretary of the Coventry Section.

Mr. Jack Merkine, Associate Member, has terminated his contract with the Israel Government and has joined Koor Industries & Crafts Limited, as Head of the Equipment and Maintenance Department. Mr. Merkine is the Institution's Corresponding Member for the Middle East.

Mr. E. R. Nicholls, Associate Member, has now taken up an appointment with the Ministry of Labour and National Service as a Deputy Manager of the Government Training Centre and Industrial Rehabilitation Unit at Leicester.

Mr. C. J. Pratt, Associate Member, has now taken up an appointment with Dorr-Oliver Incorporated Organisation, Stamford, Connecticut, U.S.A., as a Senior Chemical Engineer.

Mr. B. E. Price, Associate Member, who was General Manager of Thos. De la Rue & Co., Fife, has now transferred to Imperial Chemical Industries Limited, Metals Division, Kynock Works, Witton, Birmingham. Mr. Price formerly served on the Dundee Section Committee.

Mr. M. H. Slater, Associate Member, is now Development Manager to The Dart Spring Company Limited, West Bromwich.

Mr. S. G. Statham, Associate Member, is now permanently attached to the Portsmouth Factory of the de Havilland Aircraft Co. Ltd.

Mr. G. J. Willmott, Associate Member, has recently joined the Board of the Gear Grinding Co. Ltd., Shirley, Solihull, and now holds the position of Director and General Manager. Mr. Willmott was previously General Manager.

Mr. J. F. A. Bryen, Graduate, has relinquished his position as Head of the Data Processing Section with A.E.C. Limited, Southall, to join the British Tabulating Machine Company Limited, as Production Control Department Investigator.

Mr. R. Carrie, Graduate, has been transferred by his Company, Singer Manufacturing Co. Ltd., to their factory in Karlsruhe, Germany, for a period of two years to study their methods.

Mr. F. L. Hiles, Graduate, has now left Hawker Aircraft Limited, and has taken up the position of Technical Assistant to the Chief Engineer with Felt & Tarrant, Limited.

Mr. C. W. Lewis, Graduate, is now employed at Product Engineering & Designs, Birmingham.

Mr. R. W. Morgan, Graduate, is now employed by I.C.I. Billingham Division as a Technical Officer (Engineering).

Mr. R. T. Mustard, Graduate, has relinquished his position as Chief of Methods Planning Section at Marconi's Wireless Co. Ltd., Basildon, Essex, to join The Shandon Scientific Co. Ltd., London, as their Technical Manager.

Mr. G. W. Voaden, Graduate, has relinquished his appointment with Messrs. F. Bode & Son, Limited, Leek, Staffs., and is now Mechanical Engineer with Thomas Bolton & Sons Limited, Froghall, Stoke-on-Trent.

Hazleton Memorial Library

REVIEWS

"Practical Metrology" by K. J. Hume and G. H. Sharp. Volume II. *London, MacDonald & Company Limited,* 1955. 71 *pages. Diagrams.*

This book is the second of four volumes describing experiments in metrology. The first volume was reviewed in this Journal in April, 1954.

This second volume describes 12 further experiments which may be undertaken by a moderately advanced student of metrology. The subjects covered include the complete measurement of screw plug and ring gauges, certain aspects of gear measurement, use of a comparator, and the use of a sine bar and gauge projector. Several pages are devoted to the preparation of master drawings for projectors.

There is no doubt that the high standard attained in the first volume has been maintained in the second. In their text the authors have given many warnings against pitfalls. These should be gratefully accepted by students, since many of them have not been published previously.

This reviewer feels inclined to disagree with the suggestion on page 40 that the "finishing rods" provided for supporting thread measuring cylinders on a screw measuring machine should be discarded. It is felt that the average student would spend too much of his precious laboratory time looking for dropped cylinders. On the other hand, it is agreed that the professional operator could use the suggested method with advantage.

On page 28 the formula for the radius of a plate gauge is given as $(e^2 + h^2)/2h - d/2$. This is the usual formula. The student with limited mathematical knowledge might get into trouble and introduce relatively large errors into his answer if the formula is used in this form, and the modified formula $e^2/2h + h/2 - d/2$ might be more convenient for students' use.

There is no doubt that the second volume will join the first on the bookshelves of many metrology students, teachers, and also engineering inspectors. It is hoped that the promised third and fourth volumes will not make such a belated appearance as the second. S.R.S.

"Practical Plant Layout" by Richard Muther. *New York, MacMillan,* 1955. 359 *pages. Diagrams.*

This book from the U.S.A. deals in a most detailed manner with the practical problems in preparing manufacturing plant layouts.

In four main sections which are treated in logical sequence, it outlines the analytical requirements of a sound layout. In doing so, it touches upon a large sector of the complete field of pre-production planning including machine loading and utilisation, operation layouts, flow analysis, manufacturing economics, motion economy, time study, etc. After showing how to marshal and determine the facts upon which to base the layout, Mr. Muther gives a comparative assessment of the alternative methods of layout presentation : by drawings, by templates, three-dimensional models, etc. All companies who spend considerable technical man-hours preparing drawings for plant layout and installation should take note of the use of templates of "silhouettes", followed by the photographic method of presenting working instructions without recourse to the drawing board.

In covering the ancillary subjects, there is a tendency to over-simplification: in the section on time study, the author confines himself to an example showing the application of the M.T.M. system of standard-times or "synthetics" which could, to those not familiar with standard-time systems, suggest that one is completely safe and accurate in applying this type of system for practical estimation. The accuracy of these systems over the full range of manufacture has, in fact, yet to be proved.

The other main criticism is that the author, in this reviewer's opinion, has not given sufficient attention to the implications on factory layout resulting from the use of palletised unit loads and fork trucks.

The presentation is first-class and has an abundance of diagrams, charts and illustrations.

This book should undoubtedly find a wide field of interest from British factory management and planning engineers. It contains a wealth of information on American practice which could, with considerable advantage, be taken up in this country. E.C.

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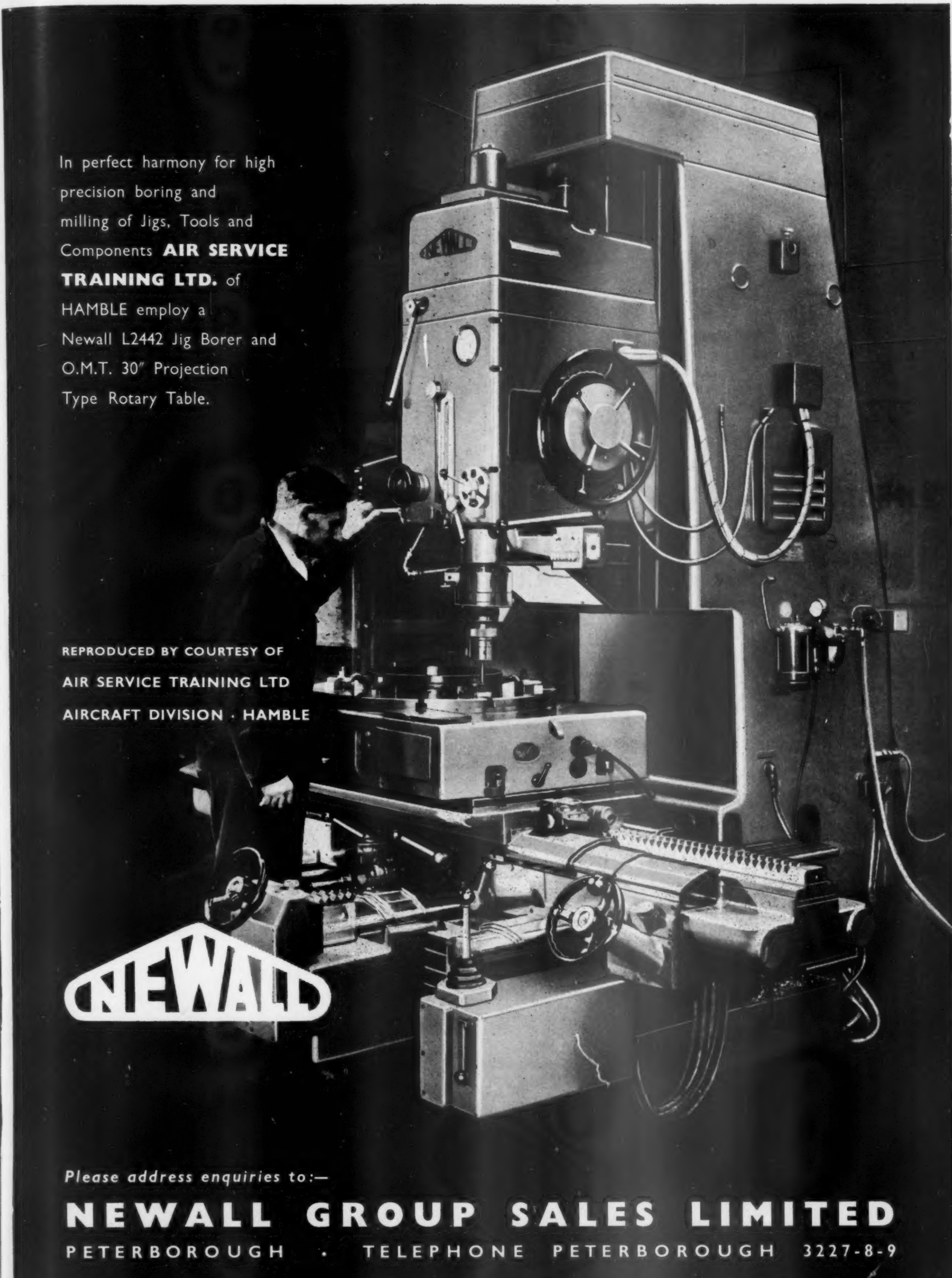
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With Rack Conveyor Systems you bring order out of chaos, help speed assembly or machining and save operator's time. Because of the usable vertical space provided, the Rack method affords as much as six times the working capacity for every square foot of floor space it occupies!

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Largest dia. of component (Steel) ..	.236″
Maximum length of component ..	2.952″
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Maximum face width	1.575″
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THE 600 GROUP

ZBROJOVKA Millers

Complete rigidity at high machining speeds

The illustration shows a Zbrojovka Miller FA5V machining an aircraft main wing spar web from solid billet. It is installed in the Works of Messrs. C. J. C. Developments (Portsmouth) Ltd., Farlington, Portsmouth, by whose courtesy this picture is published.

Brief Specifications of Horizontal, Universal and Vertical Millers

Sizes:	No. 2	No. 3	No. 4	No. 5
Working surface of table (approx.)	40″x 8″	50″x 10″	64″x 12″	80″x 16″
Power longitudinal travel (approx.)	25″	32″	40″	50″
Power cross travel (approx.)	8″	9″	12″	16″
Spindle speeds ...	63-2800	45-2000	32-1400	18-1400

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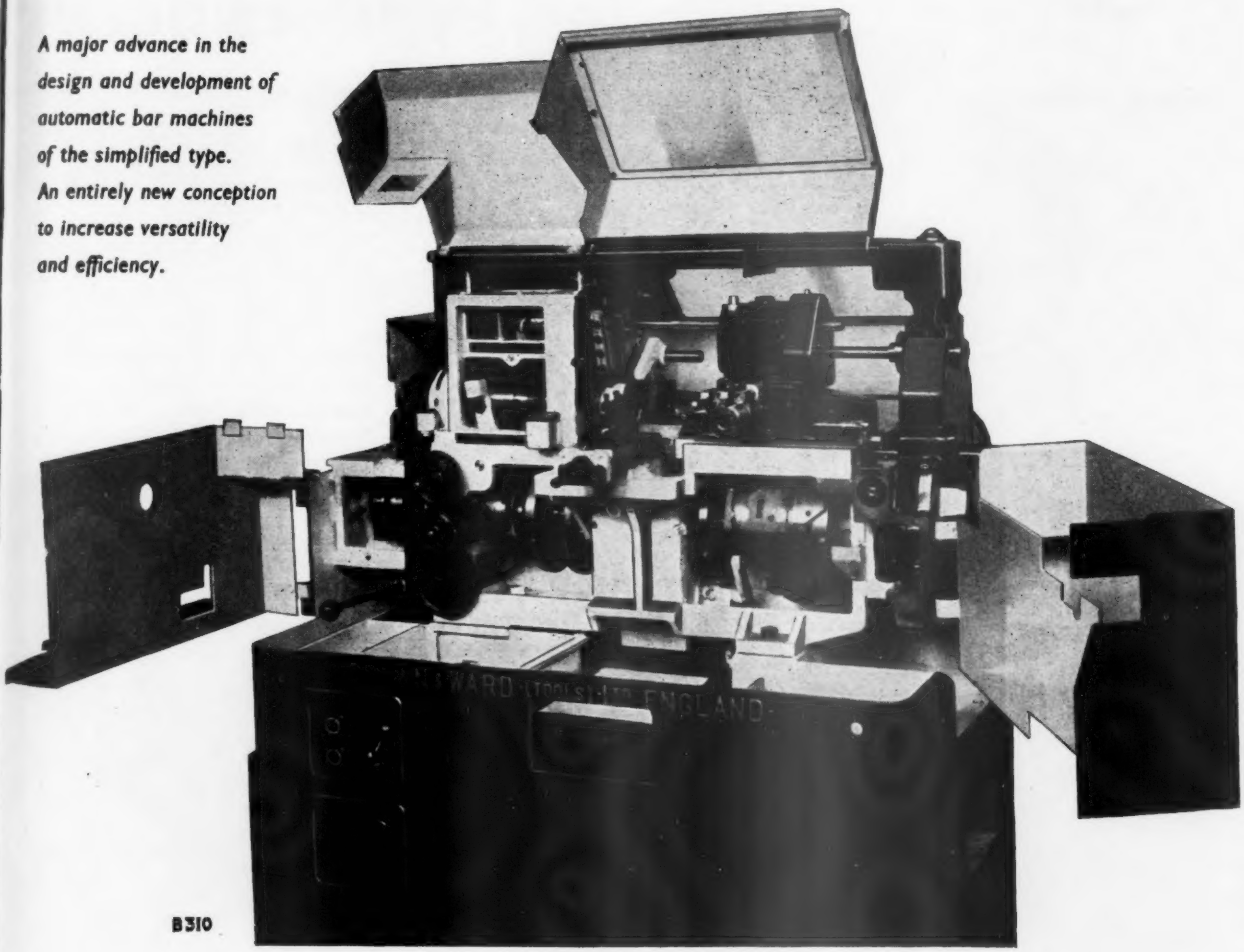

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the FIRST *practical* applications of SPARK EROSION machining—

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SPARCATRON

Now, over three-hundred SPARCATRON applications are operating throughout the world

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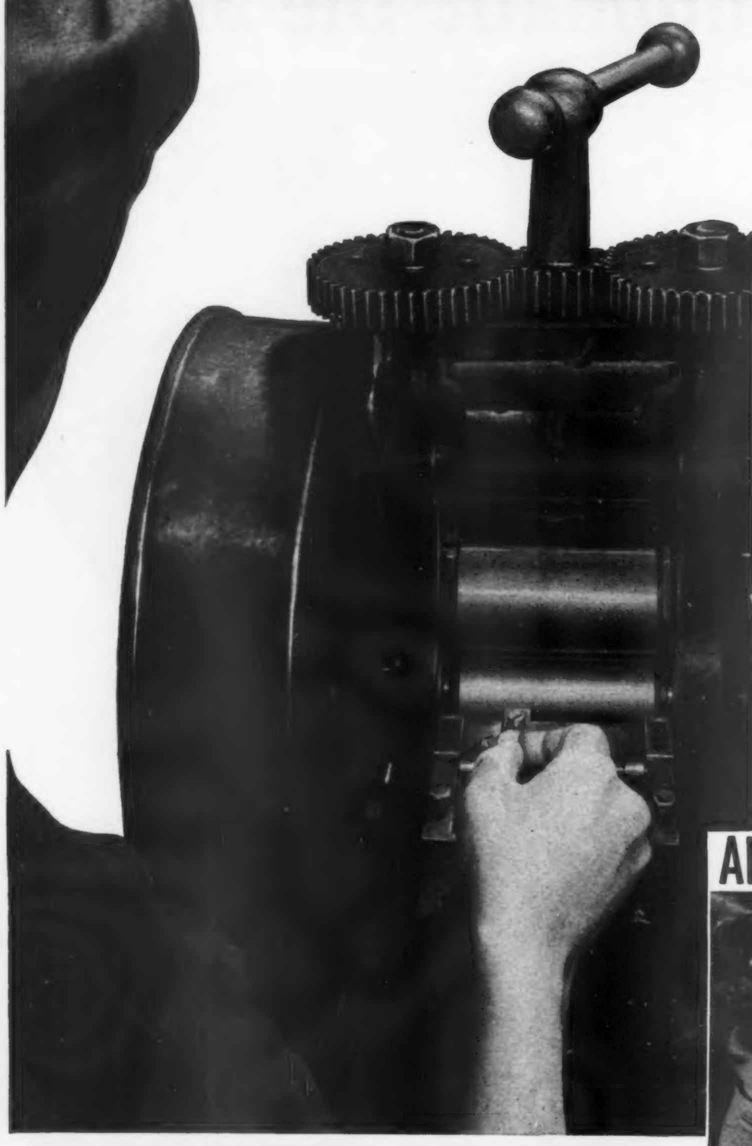
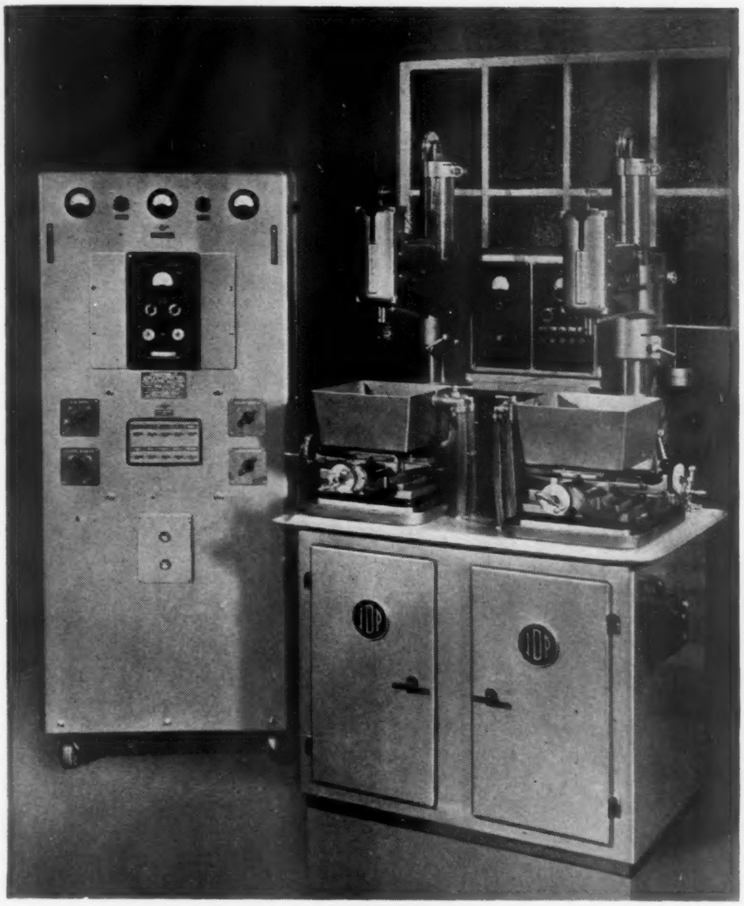
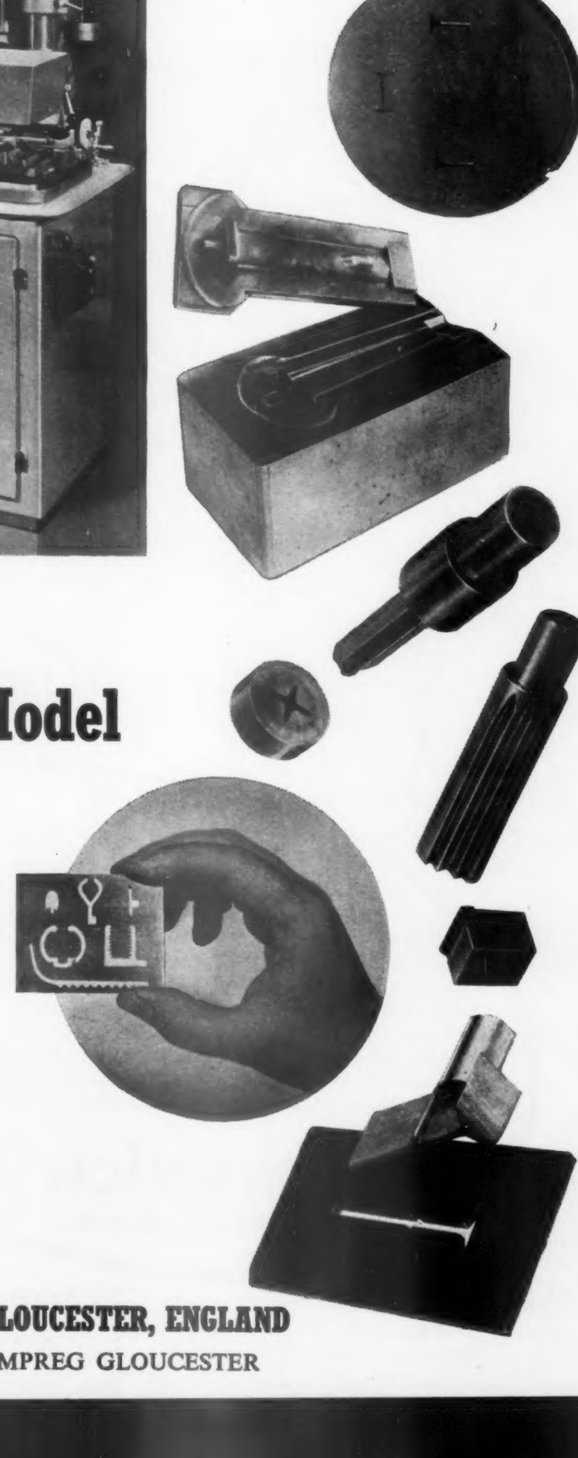




For production of all types of dies and form tools.



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SPARCATRON Mk. II Model

With double head.

This addition to the Sparcatron range of machines for spark machining has been produced as the result of requests for an equipment for use with large section electrodes to be operated to very close limits, and can be supplied with two heads as illustrated, or with a single head.

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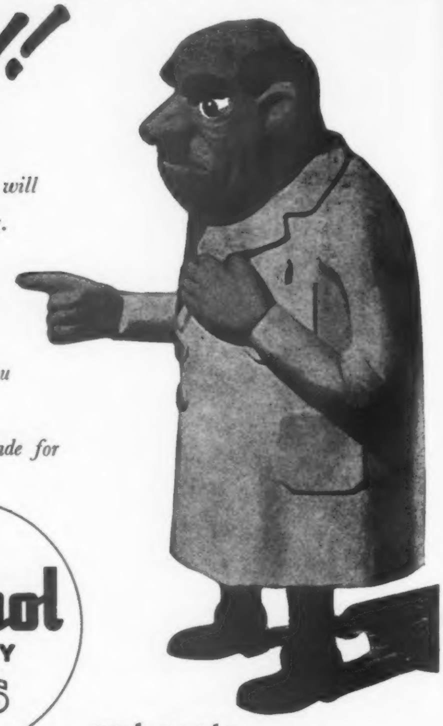


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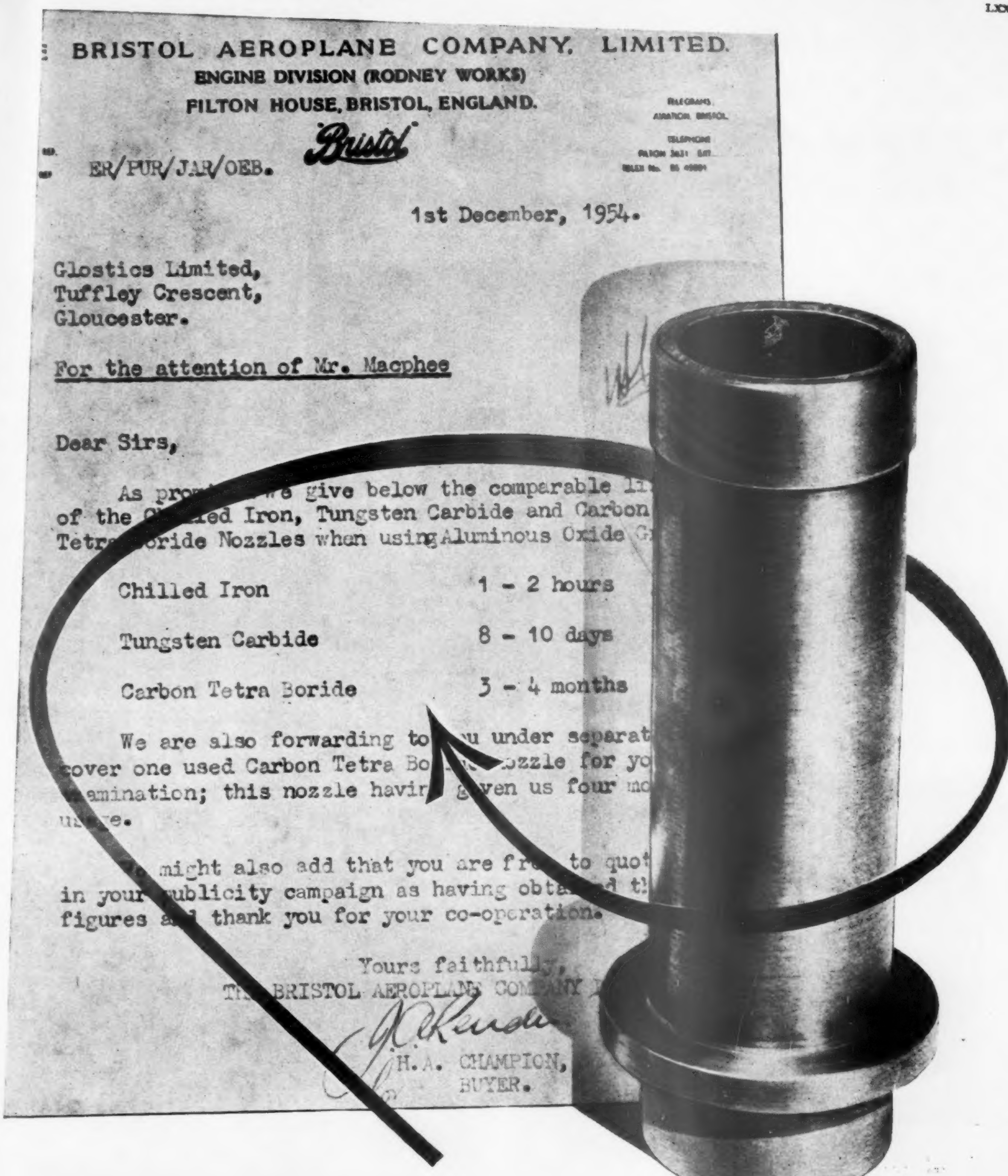

CTB nozzles outlast them all

Glostics Ltd

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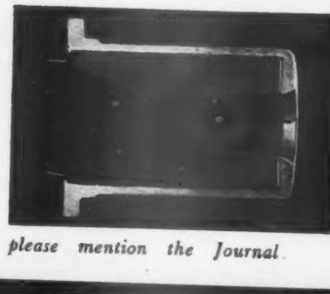

A 1/16″ bore Carbon Tetra Boride Nozzle with tapered lead-in after four months use with alumina shot. Note:—The bore at the nozzle throat is only 1/32″ larger than when new.

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This rare bird is made up of an odd assortment of items, all of which, however, have three things in common :-

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2. **THEY ALL HAVE AN U.T.S. OF 8/9 T.S.I. (P.V. = 434,000).**
3. **THEY'RE ALL MADE TO CUSTOMERS SPECIFICATIONS BY M.P.C.**

MPC

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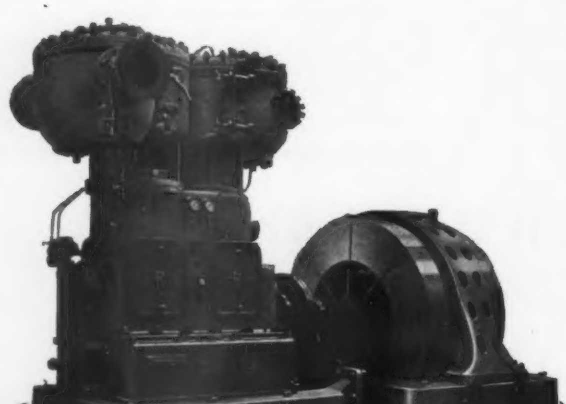

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